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US ARMY
TEST & EVALUATION COMMAND

USATECOM PROJECT NR 4-4-7475 (AB 5563)

FINAL REPORT
OF INTEGRATED ENGINEERING/SERVICE TEST
OF
LOW LEVEL EXTRACTION TECHNIQUES (LOLEX)
FROM CV-2B AIRCRAFT

8 September 1964

"FOR INFORMATION ONLY, ACTION BY HIGHER AUTHORITY PENDING"

US ARMY
AIRBORNE, ELECTRONICS & SPECIAL WARFARE BOARD
FORT BRAGG, NORTH CAROLINA

HEADQUARTERS
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Fort Bragg, North Carolina 28307

FINAL
REPORT OF
INTEGRATED ENGINEERING/SERVICE TEST OF
LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT

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ABSTRACT

This report of test includes results of flight safety, engineer, and service test of Low Level Extraction Techniques (LOLEX) for air delivery of Army supplies and equipment from CV-2B aircraft. Tests Nr 1 and 4 - 9 were the service test phase of the test conducted by the USAAESW Board, Executive Test Agency, under field conditions at Fort Bragg, North Carolina, during the period 26 May to 26 June 1964. Test Nr 2 was the flight engineer test phase conducted by USAATA, Supporting Test Agency, at Edwards AFB, California, during the period 10 March to 3 April 1964. Test Nr 3 was the engineer test phase conducted by YPG, Supporting Test Agency, at Yuma, Arizona, during the period 6 - 29 April 1964. The USAAVNTB, Supporting Test Agency, with primary interest in aircraft operations and crew procedures, participated in all tests. The USAQMS (ABN), with primary interest in publication of techniques and procedures, observed all service tests. A deficiency in the pendulum release system exists. Suitable flight safety and operational parameters, procedures, and techniques were determined and recommended for Army use, provided recommended modifications to insure safety and reliability are incorporated.

SECTION 1 - GENERAL

1.1 REFERENCES

See Appendix VII, References.

1.2 AUTHORITY

Letter, AMSTE-BG, U. S. Army Test and Evaluation Command, 29 November 1963, subject: "Directive for Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft. USATECOM Project Nr 4-4-7475" (Appendix I).

1.3 OBJECTIVES

The objective of this test is to determine suitability of LOLEX as a standard U. S. Army system for air delivery of cargo. Special consideration should be given both to safety and reliability with particular attention on:

a. Aircraft control.

b. Stress upon loads.

c. Rigging procedures.

d. Pilot techniques.

1.4 RESPONSIBILITIES

See Appendix I, Test Directive.

1.5 DESCRIPTION OF MATERIEL

The Low Level Extraction Techniques (LOLEX) is an adaptation of the standard air drop system used with CV-2B aircraft. LOLEX incorporates, insofar as is practicable, standard air drop system components and rigging techniques. There are, however, some very significant differences in procedures and delivery techniques. Extraction of the load is accomplished by parachute while the aircraft is flying close to the ground and at reduced speed, thereby eliminating the requirement for recovery (cargo) parachutes. The extraction parachute also serves to stabilize the load during its short descent and to reduce the load's forward momentum from time of deployment until the load comes to rest.

1.6 BACKGROUND

1.6.1 Due to universally improved antiaircraft weaponry and the resultant vulnerability of relatively slow flying aircraft, and in the absence of landing sites in combat areas, a low altitude method of delivering supplies and equipment into combat areas by air is desired.

1.6.2 During the period January - March 1963, U. S. Army Natick Laboratories, in conjunction with the USAAESW Board and other interested Army agencies, conducted an expedited evaluation of ground-based extraction systems. Testing was terminated when it was determined that the ground-based systems presented unacceptable safety hazards.

1.6.3 During Exercise Swift Strike III, August 1963, a detachment from the Airborne Department, U. S. Army Quartermaster School, Fort Lee, Virginia, in coordination with the 11th Air Assault Division, Fort Benning, Georgia, demonstrated the basic LOLEX concept as described in paragraph 1.5, above. After Exercise Swift Strike III, other Army units used the LOLEX concept with varying degrees of success. These operations indicated the need to test the system, with particular attention to safety and reliability, to determine its suitability as a standard air delivery system for Army use and, if appropriate, to determine standard procedures and techniques.

1.6.4 In November 1963, USATECOM was directed by AMC to conduct a test of LOLEX for the purpose stated in paragraph 1.3, above.

1.7 FINDINGS

a. There is no formally stated requirement for a Low Level Extraction Technique contained in the Combat Developments Objective Guide. Basic criteria for the Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) were established at a coordination meeting held at Headquarters, USATECOM, 8 January 1964. In those areas where no definitive guidance was available, criteria were established by the USAAESW Board.

b. LOLEX for CV-2B aircraft consists of the following standard components:

(1) Combat expendable air drop platforms, 70-inch width, in lengths of 8 to 14 feet.

(2) Paperboard honeycomb energy dissipator.

(3) Tiedown straps and load binders.

(4) Cargo slings and clevises.

(5) Ringslot extraction parachute, 22-foot.

(6) Extraction line, 60-foot, 6-ply.

(7) Pilot parachute, personnel type, 2' 2" diameter.

(8) Pilot parachute, cargo type, 5' 8" diameter.

c. A nonstandard, locally fabricated, pilot parachute bag was incorporated into LOLEX.

d. The standard CV-2B aircraft was used. However, the pendulum release system currently installed in CV-2B aircraft was not sufficiently reliable for LOLEX. The pendulum release system as modified during tests was reliable. The pendulum release switch, as presently installed in CV-2B aircraft, could not be safely actuated by the pilot and was awkward and difficult for the copilot to reach.

e. Best results were obtained with LOLEX when the aircraft was in the following flight profile:

(1) Landing gear down, cargo door open, ramp level, and wheel-to-ground clearance of 3 to 6 feet.

(2) A flight attitude which placed the cargo floor (longitudinal axis of the aircraft) parallel to the terrain of the drop zone.

(3) Symmetrical power on both engines.

(4) Coordinated flight (for cross wind correction using crab rather than slip techniques).

(5) Minimum air speed of 80 knots IAS unless gross weight required higher speed.

f. The 22-foot ringslot extraction parachute provided better load orientation than the 15-foot ringslot extraction parachute. Deployment time of the 22-foot ringslot extraction parachute was decreased when pilot parachutes were used in conjunction therewith.

g. Items of Army supplies or equipment, within the weight range of 1,000 to 4,000 pounds, suitable for delivery by the standard air drop system, were delivered by LOLEX.

h. Load survivability was increased when the load impacted at a stable 5 - 10 degrees nose-up attitude. This load attitude was influenced by center of gravity and extraction point location.

i. Five loads, less than 2,000 pounds each, lifted a maximum of 4 inches as they were extracted over the ramp. Loads of less than 2,000 pounds and 55 inches high and loads of 2,000 to 4,000 pounds and 61½ inches high did not strike the aircraft during extraction.

j. Drop zone requirements for LOLEX under test day conditions and varying terrain at Fort Bragg, North Carolina, were 480 feet for the impact area and an additional 500 feet per 50 feet of barrier at the approach and at the departure corridors. Corridor air space required a minimum width of 135 feet. An impact area, 30 feet wide, cleared of major obstructions, was required for load survivability. Drop zone requirements would vary significantly with changes in gross weight, air speed, and altitude.

k. LOLEX complied with all of the test criteria except that load survivability in ground winds in excess of 16 knots was not tested.

l. Methods, techniques, and components of LOLEX that contained elements of an unsafe condition were eliminated so that no unacceptable safety hazards existed when employed within the parameters established.

1.8 CONCLUSIONS

a. LOLEX from CV-2B aircraft is considered sufficiently reliable and safe to be suitable for Army use when flight safety and operational parameters, procedures and techniques, and modifications derived and employed in this test are used.

b. Relocation of the cockpit pendulum release switch is desirable for LOLEX operations.

c. Additional testing should be accomplished to define CV-2B LOLEX performance for all operating conditions.

1.9 RECOMMENDATIONS

a. That the Low Level Extraction Techniques (LOLEX) from CV-2B aircraft be considered suitable for Army use provided:

(1) The flight safety and operational parameters derived and employed in this test are used.

(2) The procedures and techniques derived and employed in this test are used.

(3) The pendulum release system in CV-2B aircraft is modified to insure a positive ejection of the extraction parachute beyond the aircraft ramp.

b. That the pendulum release system for CV-2B aircraft be modified as indicated in Appendix IV and tested.

c. That the cockpit pendulum release switch be relocated as indicated in Appendix IV.

d. That the appropriate agency develop and provide a single pilot parachute bag as recommended in Appendix IV.

e. That procedures and techniques for employment of the Low Level Extraction Technique (LOLEX) be published at the earliest practicable date.

f. That recommended procedures and techniques contained in Appendices IX and XI be incorporated into existing manuals as appropriate at the earliest practicable date.

g. That further testing of LOLEX be conducted to define CV-2B LOLEX performance for all operating conditions.

SECTION 2 - DETAILS AND RESULTS OF SUB-TESTS

2.0 INTRODUCTION

2.0.1 Tests Nr 1 and 4 - 9 were the service test phase of the test conducted by the USAAESW Board, Executive Test Agency, under field conditions at Fort Bragg, North Carolina, during the period 26 May to 26 June 1964. Tests were conducted by key personnel listed in Appendix VIII.

2.0.2 Test Nr 2 was the engineer test phase conducted by U. S. Army Aviation Test Agency (USAATA), Supporting Test Agency, at Edwards AFB, California, during the period 10 March to 3 April 1964.

2.0.3 Test Nr 3 was the engineer test phase conducted by Yuma Proving Ground (YPG), Supporting Test Agency, at Yuma, Arizona, during the period 6 - 29 April 1964.

2.0.4 The U. S. Army Aviation Test Board (USAAVNTB), Supporting Test Agency, with primary interest in aircraft operations and crew procedures, participated in all tests.

2.0.5 The U. S. Army Quartermaster School (USAQMS) (ABN), with primary interest in publication of techniques and procedures, observed all service tests.

2.1 TEST NR 1 - BACKGROUND STUDY

2.1.1 OBJECTIVE

Determine, by study, the existence of formally stated military requirements for LOLEX, the system's physical characteristics, and experience factors reference its use.

2.1.1.1 Criteria

a. Components used in LOLEX shall consist of standard items where practicable (paragraph 1, Appendix III).

b. Extraction will be accomplished while the CV-2B aircraft is flying close to the ground and at reduced speed, thereby eliminating the necessity for recovery (cargo) parachutes (paragraph 2, Appendix III).

2.1.2 METHOD

a. Research was conducted to determine if formally stated requirements for such a system exist.

b. U. S. Army agencies, which had employed a LOLEX concept, were solicited for experience factors based upon its operational use.

c. The information gathered was evaluated against known safety and reliability factors used in standard air drop techniques.

2.1.3 RESULTS

a. There is no formally stated requirement for a Low Level Extraction Technique contained in CDOG. Basic criteria for the Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) were established at a coordination meeting held at Headquarters, USATECOM, 8 January 1964. In those areas where no definitive guidance was available criteria were established by the USAAESW Board.

b. LOLEX is an adaptation of the standard air drop system. Extraction of the load is accomplished by extraction parachute while the aircraft is flying close to the ground and at reduced speed thereby eliminating the need for recovery (cargo) parachutes. The extraction parachute also serves to stabilize the load during its short descent and to reduce the load's forward momentum from time of deployment until the load comes to rest.

c. There were no standard methods for employment of a Low Level Extraction Technique. Units were using low level extraction adaptations under varying conditions to include:

(1) Air speeds from 55 to 100 knots.

(2) Aircraft configurations to include ramp level and ramp down, flap settings from 0 to 25 degrees, landing gear up and landing gear down.

(3) Loads varying in configuration and rigged on platforms and skidboards in sizes from 48" x 48" to 70" x 144".

(4) Extraction parachutes varying from the reefed 15-foot extraction parachute to the unreefed 28-foot extraction parachute.

(5) Extraction lines varying in length from 40 to 60 feet.

(6) Emergency procedures used for standard air drop.

2.1.4 ANALYSIS

a. The varied applications of the Low Level Extraction Technique indicated in many instances the existence of flight safety hazards.

b. The study and evaluation indicated that there was a requirement to standardize and implement safe operating procedures and techniques for LOLEX from CV-2B aircraft.

2.2 TEST NR 2 - SAFETY OF FLIGHT AND OPERATIONAL PARAMETERS (ENGINEERING TEST) (USAATA)

2.2.1 OBJECTIVE (paragraph 3, Appendix IX)

"The objective of this evaluation was to investigate the flying qualities and performance of the CV-2B airplane during LOLEX operations, to develop a suitable LOLEX airplane configuration and flight envelope, and to define safety-of-flight considerations pertinent to LOLEX operations."

2.2.2 METHOD

See paragraph 5, Appendix IX.

2.2.3 RESULTS

a. For detailed results, see section II, Appendix IX.

b. The following are USAATA findings (paragraph 6, Appendix IX).

"a. Performance, stability and control characteristics of the CV-2B airplane were suitable for LOLEX operations.

"b. The following airplane configurations yielded satisfactory approach attitudes, performance, and flying qualities:

"(1) For Approach Speeds Up to 85 Knots IAS:

"(a) Landing gear - down
"(b) Flap setting - 15 degrees
"(c) Power - as required for level flight.

"(d) Propeller control - takeoff rpm setting
"(e) Ramp door - level
"(f) Cargo door - open
"(g) Autofeathering - off

"(2) For Approach Speeds Above 85 Knots IAS:

"(a) Landing gear - down
"(b) Flap setting - 7 degrees
"(c) Power - as required for level flight
"(d) Propeller control - takeoff rpm setting
"(e) Ramp door - level
"(f) Cargo door - open
"(g) Autofeathering - off

"c. The following flight envelope yielded satisfactory airplane performance, flying qualities and drop pitch attitudes when the airplane was operated in the configurations listed in 6 b:

"(1) Minimum LOLEX Approach Speeds

"(a) 24,000 pounds - 75 knots IAS
"(b) 26,000 pounds - 83 knots IAS
"(c) 28,500 pounds - 90 knots IAS

"(2) Maximum LOLEX Approach Speeds

"(a) At 15 degree flap settings - 92 knots IAS
"(b) At 7 degree flap settings - 100 knots IAS

"(3) Airplane Gross Weight Range

"All gross weights between 24,000 pounds and the maximum authorized gross weight of 28,500 pounds.

"(4) Airplane C.G. Range

"As specified in Reference f.

"(5) Single Load Weight Range

"All load weights up to a maximum of 4150 pounds.

"d. The CV-2B airplane did not possess adequate performance for prolonged flight with either a 15-foot or a 22-foot extraction parachute deployed. This result indicated a requirement for a device which could be used to separate a hung extraction parachute from the airplane.

"e. Adequate single-engine performance and control could be consistently obtained following an engine failure during the LOLEX drop sequence provided that the airplane configurations and flight envelope given in 6b and 6c were employed and that the following procedure was utilized following the failure:

"(1) A modified, pilot-induced "zoom" to a speed not lower than the minimum single engine control speed for the appropriate weight as listed in Reference f.

"(2) Jettison of cargo with the extraction system (if necessary).

"(3) Application of both throttles to takeoff power settings.

"(4) Feathering of failed engine.

"(5) Retraction of landing gear.

"(6) Retraction of flaps in steps.

"f. Balanced (ball-centered) rather than yawed flight should be maintained during the LOLEX drop sequence to preclude load contact with the interior side walls of the airplane during load extraction.

"g. A tactical LOLEX approach, drop and climb-out over 50-foot barriers, as executed in these tests, would require a minimum field length of approximately 1460 feet at a gross weight of 28,000 pounds using an approach airspeed of 90 knots IAS at an altitude /field pressure/ of 2300 feet.

"h. The pendulum release switch, as presently installed in the CV-2B, could not be safely actuated by the pilot and was awkward and difficult for the copilot to reach.

"i. The time required for actual load extraction following actuation of the extraction system was too long and reduced drop accuracy.

"j. All performance results presented in this report are for test day conditions only. Considering the significant effect of varying atmospheric conditions on airplane performance, sufficient additional engineering tests should be accomplished to completely define CV-2B LOLEX performance parameters for all operation conditions."

2.2.4 ANALYSIS

a. See USAATA report, Appendix IX.

b. USAAESW Board Comments: This Board concurs with the above findings with the following exceptions:

(1) Reference paragraph d: The U. S. Army Aviation Test Agency indicates a requirement for a device which could be used to separate a hung extraction parachute from the airplane. This Board, based upon the U. S. Army Aviation Test Board report (Appendix XI to this report) and results during service tests, finds that modifications to LOLEX components and rigging procedures developed and used in service tests either eliminate or greatly reduce the probability of a hung extraction parachute or load. The requirement for a device which could be used to separate a hung parachute from the airplane is therefor no longer valid.

(2) Reference paragraph i: The U. S. Army Aviation Test Agency finds that the time required for actual load extraction following actuation of the extraction system was too long and reduced drop accuracy. This deficiency was corrected (Test Nr 4).

2.3 TEST NR 3 - SUITABILITY AND PARAMETERS FOR USER TEST (ENGINEERING TEST) (YPG)

2.3.1 OBJECTIVE (paragraph 1.3, Appendix X)

"a. To determine reliability for U. S. Army use of LOLEX method of air delivery using the CV-2B aircraft with particular emphasis upon load survivability.

"b. To obtain sufficient engineering data to establish recommended procedures for use with the LOLEX system with specific attention to rigging procedures and effect of aircraft flight characteristics and parameters."

2.3.2 METHOD

See paragraph 2.1, Appendix X.

2.3.3 RESULTS

a. For detailed results, see Section 2, Appendix X.

b. The following are YPG findings (paragraph 1.7, Appendix X):

"1.7.1 GENERAL

"Fluctuation of meteorological wind conditions, variation in drop zone characteristics and variation in type air delivery loads negate performance of LOLEX operation in a truly precision or precise manner. Within the limits of precision normally attainable with consideration to derived flight safety and operational parameters, load survivability is comparable to that of conventional air delivery systems employing retardation parachutes.

"1.7.2 LOAD STABILITY

"During descent, and with reference to the ground, the LOLEX load maintains significant forward speed. The load maintains good lateral stability, inherently, unless the aircraft had been in transient instability during extraction and tip-off. The load may or may not attain a near-stable pitch attitude before, or at, touchdown, depending on factors to be discussed in Appendix II. Load survivability is more predictable when the load has a specific stable pitch attitude at touchdown.

"1.7.3 IMPACT CHARACTERISTICS

"On impact, the g forces due to horizontal speed and/or load rotation are significant factors in load survivability (Fig 1). The minimization of these forces and/or their effects is essential and will be discussed in Appendix II.

"1.7.4 DROP ZONE LENGTH

"A minimum length of 400 to 500 feet should be relatively level and cleared of airspace obstructions - half of which should be as clear and level as practical, based on effort required versus load survivability.

"1.7.5 DROP HEIGHT

"The drop height for loads in the 4000-pound range should not be over 15 feet (11 feet of gear-down clearance) graduating downward to the minimum feasible height. Preferable drop heights are 8 or 10 feet (4 or 6 feet of gear-down clearance) for rough surfaces, and 7 or 8 feet (3 or 4 feet gear-down clearance) for flat or smoothly undulating surfaces.

"1.7.6 AIRCRAFT ATTITUDE SPEED AND FLIGHT PATH

"The preferable aircraft attitude speed is 80 knots IAS unless gross weight requires higher speed; the preferable flight

path is straight, level and steady, with cargo floor horizontal and ramp position level. Crab rather than side-slip when necessary to follow drop zone surface contours in cross wind. The load will not sideswipe aircraft if the parachute pulls slightly to one side. As an expedient only, use nose-up attitude for high drop heights and faster speeds (85 to 90 knots) for heavier loads with centered or forward center of gravity.

"1.7.7 AIR DELIVERY SYSTEM CHARACTERISTICS

"Optimum platform length is 96 inches long and 70 inches wide for weight ranges tested. Load should be distributed uniformly when feasible, with the center of gravity centered laterally, approximately 6 inches aft of center of platform, and as low as practical. Attachment point of the extraction line should be at one end of the load, approximately 6 inches higher than the center of gravity. Extraction clearance is questionable for silhouettes over 60 inches high.

"1.7.8 EXTRACTION PARACHUTE

"A 22-foot ringslot extraction parachute should be used for weights of 1000 to 4000 pounds and a 15-foot ringslot extraction parachute, unreefed optional, for loads of 1000 to 2000 pounds if over 50 inches high, at aircraft speeds of 85 knots or more.

"1.7.9 EXTRACTION PARACHUTE PENDULUM RELEASE SYSTEM

"The pendulum release system as originally installed in the CV-2B aircraft is not sufficiently reliable for consistently satisfactory LOLEX operations, requiring reversal and field modification of the release hook as shown in Figure 2."

2.3.4 ANAYLSIS

a. See YPG report, Appendix X.

b. USAAESW Board Comments: This Board concurs with the above findings with the following exceptions:

(1) Reference paragraph 1.7.1: Although precision is a matter of degree, this Board finds that LOLEX performs its mission within the limits of precision required (Test Nr 5).

(2) Reference paragraph 1.7.6: Aircraft speeds recommended by USAATA (Test Nr 2) are a matter of flight safety. No deviations should be authorized.

(3) Reference paragraph 1.7.8: This Board recommends no deviation of aircraft speed vs weight recommended by USAATA (Test Nr 2) and finds that the 22-foot extraction parachute is more satisfactory than the 15-foot extraction parachute under all conditions (Test Nr 4).

2.4 TEST NR 4 - PROCEDURES AND TECHNIQUES

2.4.1 OBJECTIVE

a. Determine suitable procedures for LOLEX utilizing representative items of Army supplies and equipment.

b. Determine suitable rigging techniques for those items of Army supplies and equipment delivered by LOLEX.

2.4.1.1 Criteria

a. LOLEX shall be capable of effecting air drop of supplies and equipment in combat serviceable condition from standard U. S. Army CV-2B aircraft under the following conditions:

(1) While the aircraft is flying at the minimum feasible altitudes (paragraph 4, Appendix III).

(2) Without requirements for recovery parachutes (paragraph 4, Appendix III).

b. LOLEX shall facilitate simple and rapid rigging and derigging of loads by troops without special training and with minimum use of special materiels handling equipment (paragraph 5, Appendix III).

c. LOLEX shall provide for suitable load attitude during descent and landing (paragraph 6, Appendix III).

d. LOLEX shall ensure rapid recovery and immediate access on the ground to the supplies and equipment without hindrance from any nonstandard associated components (paragraph 7, Appendix III).

e. LOLEX shall not limit flexibility of positioning loads, with respect to aircraft center of gravity limitations (paragraph 8, Appendix III).

f. LOLEX shall require no major modifications of standard vehicles or equipment to be delivered (paragraph 9, Appendix III).

g. LOLEX shall require no major modification of air delivery items or aircraft (paragraph 10, Appendix III).

h. LOLEX shall be compatible with the CV-2B aircraft standard air drop capability (paragraph 11, Appendix III).

i. LOLEX shall be such that no components need be retrieved into the aircraft after air drop (paragraph 12, Appendix III).

j. Platforms for LOLEX shall be constructed in various lengths required for efficient delivery of Army supplies and equipment (paragraph 3, Appendix III).

2.4.2 METHOD

a. The results of Tests Nr 1, 2, and 3 were evaluated to determine any required modifications to LOLEX prior to the service test phase.

b. Using those procedures determined to be most suitable, simulated and actual representative loads of Army supplies and equipment varying in weight, height, width, and center of gravity location were delivered as single and multiple extractions from CV-2B aircraft. Delivery approaches were conducted from nap-of-the-earth and conventional flight altitudes. Aircraft wheels were down and locked; cargo ramp was in the level position.

c. Standard extraction parachutes were used to extract the loads. Extraction forces were varied.

d. Initially loads were rigged and restrained on appropriate platforms using standard procedures. Deviation from standard rigging and restraint procedures was made as required.

e. Loads were derigged and inspected for damage after each extraction. When appropriate, items of equipment were operated after each extraction.

f. Flight crews were debriefed after each mission.

g. Motion pictures were taken, studied, and evaluated.

h. Results were recorded, studied, and evaluated.

2.4.3 RESULTS

2.4.3.1 Evaluation of Tests Nr 1, 2, and 3 indicated the following modifications were required prior to initiation of the service test phase:

a. Final Restraint:

In order to remain within the flight safety parameters established (Test Nr 2) by providing a capability of jettisoning the load with the extraction system, the standard method of attaching the final restraint to the aft end of the platform (Section IV, TM 10-500-5) could not be used safely for LOLEX (Appendix IX). As a solution, the final restraint was placed forward of the load to permit emergency measures of severing the final restraint without the unsafe act of requiring personnel to go aft of the load. Also, in lieu of the standard method of using a shear knife to sever the final restraint, 1,000-Lb Tubular Nylon Webbing, ½-Inch Wide, FSN 8305-647-2890, was used without shear knife (Appendix VI.1). The extraction parachute generated sufficient forces to break the final restraints. The number of tiedown restraints and attachment points varied with the weight and rigging technique of the load. The final restraint, as modified, operated satisfactorily on 81 drops (Appendix II). For dual loads the aft load was restrained to the forward load with 1,000-pound nylon webbing in quantity less than used for final restraint of the forward load.

b. Modification to Pendulum System:

(1) Findings of the engineering test (Test Nr 3) indicated unreliability of the standard pendulum release installation in the CV-2B aircraft. Additional tests were conducted at this Board to determine whether the extraction parachute cleared the ramp, in the level position, when using the CV-2B aircraft pendulum system. When the extraction parachute was properly installed, in accordance with TM 10-500-5, the 15-foot extraction parachute cleared the ramp during each of 25 drops; however, the 22-foot extraction parachute hit the ramp during each of 20 drops. When the extraction parachute was installed with the pendulum line too tight, both the 22-foot and 15-foot extraction parachutes bound in the shackle and did not release.

(2) During the engineer phase of test, a modification to the standard system was made. The pendulum ejector rack was turned around (forward to aft - aft to forward) to provide a more positive release. This required placement of a pulley in the vicinity of the pendulum line hook to provide the required direction

of pull for manually actuating the pendulum ejector rack. A modified pendulum line hook, approximately 10 inches long, was fabricated for replacement of the standard hook. The modified hook extends away from the pendulum ejector rack, thereby providing a longer pendulum arm and more positive throw of the parachute (Test Nr 3 and Appendix VI.2). This modified system was reliable and was used during all subsequent tests.

c. <u>Use of Pilot Parachute</u>:

(1) Findings of the engineer test (Test Nr 2) indicated that the time required for actual load extraction following actuation of the extraction system was too long and reduced drop accuracy.

(2) The sequence of events in LOLEX method of delivery which affected the required drop zone lengths were:

(a) Deployment of the extraction parachute.

(b) Load extraction and descent to impact.

(c) Dissipation of the horizontal momentum (slide).

(3) Load extraction and slide requirements, in terms of ground distance, could be predicted with reasonable accuracy. However, deployment time for the extraction parachute, in terms of ground distance, was inconsistent and excessive. During the engineering phase of tests, the deployment distance averaged 390 feet. This average included a maximum recorded distance of 1,600 feet when a squidding action of the extraction parachute occurred. The extraction parachute deployment was unacceptable for the degree of reliability required of LOLEX to operate in small areas. To reduce this deployment distance and, if possible, to minimize occurrence of a squidding action of the extraction parachute, drag tests of the 15-foot and 22-foot extraction parachutes, with pilot parachutes attached, were conducted with the following results:

(a) When the Pilot Parachute, Personnel Type, 2' 2" Diameter, FSN 1670-251-6604, was attached to the extraction parachute, the average deployment ground distance of four trials (two with 22-foot parachute and two with 15-foot parachute) was 270 feet, with a range spread between 240 feet and 350 feet.

(b) When the Pilot Parachute, Cargo Type, 5' 8" Diameter, FSN 1670-216-7297, was attached to the extraction parachute, the average deployment ground distance of four trials (two

with 22-foot parachute and two with 15-foot parachute) was 175 feet, with a range spread between 125 and 225 feet.

(c) When the 2' 2" pilot parachute was attached to the apex of the 5' 8" pilot parachute, which in turn was attached to the extraction parachute, the average deployment ground distance of four trials (two with 22-foot parachute and two with 15-foot parachute) was 135 feet with a range spread between 120 and 150 feet.

(4) To preclude a possible squidding action, the 5' 8" pilot parachute was attached to the extraction parachute with 80-pound cotton webbing, ¼-inch. The tie breaks upon full deployment of the extraction line and after the extraction parachute is pulled from its bag (Appendix VI.3).

(5) To deploy the pilot parachutes, a locally fabricated pilot parachute bag was tied to the extraction parachute bag. A locally fabricated pin attached to a 36-inch length of Type 3 Nylon Cord (550 cord), permanently anchored to the aircraft, was inserted in the pilot parachute bag release cone. When the extraction parachute is released, the pin pulls from the release cone and permits the pilot parachutes to spring out of the bag and into the slipstream (Appendix VI.4).

(6) Use of the pilot parachutes dictated the need for change of the installation of the safety line from that described in TM 10-500-5. The safety line was passed through the bent V-ring of the extraction parachute <u>AND OVER THE PENDULUM EJECTOR RACK</u> to prevent the extraction parachute from falling to the aircraft floor and activating the pilot parachute if accidentally released.

2.4.3.2 Eighty-one loads were dropped within the flight safety envelope described in Test Nr 2. Load weights varied from 920 to 4,130 pounds (Appendix II).

a. <u>Rigging and Loading</u>:

(1) Initially, rigging techniques were those used for similar loads rigged for standard air drop. The increased horizontal velocity upon impact, introduced by LOLEX, required additional restraint to prevent the horizontal shearing of the load from the platform. For all loads, except break-away, 4 G's forward and 2 G's aft restraint to the platform were used. A piece of 3/4-inch plywood was used on each end of the load to preclude crushing by the extraction webbing (Appendix VI.5).

(2) A break-away system between 1/4-ton vehicles and platform was used because o[illegible] tendency of the load to dig in and tip over after impact or if it should strike a barrier during its slide. The break-away system is basically a load assembly which will deliberately separate (derig) in proper sequence at impact and allow the vehicle to roll rather than slide to a stop. As a general rule, one tiedown of ½-inch 1,000-pound tubular nylon was used for each 300 pounds of load weight (Appendix VI.5).

(3) Loading, positioning and restraint in the aircraft, with the exception of final restraint described in paragraph 2.4.3. 1a, and derigging was the same as for standard air drop. For vehicular break-away loads, a "gate" consisting of three 15-foot tiedown straps, anchored to the aircraft tiedown rings and attached at an apex to the center [illegible]ne cable, was used in addition to the forward buffer board assembly for final forward restraint.

b. Load Attitude During Descent:

Load survivability was optimun when the platform impacted with the ground at a stable 5 - 10 degrees nose-up attitude. Factors that influenced this load attitude during descent were:

(1) Platform Size:

The combat expendable platforms were constructed in accordance with TM 10-500 and were made 70-inches wide in all cases to prevent the probability of the load becoming lodged in the aircraft and also to provide a straight-line (parallel to longitudinal axis of the aircraft) exit of the load from the aircraft. During static tests, loads narrower than 70 inches angled when the pull was not straight (parallel to longitudinal axis of the aircraft), when the lateral center of gravity was off-center, and when the extraction point was off-center. The basic platform length, 96 inches, was determined to be the optimum for the load ranges tested. Delivery of longer platforms, required for some loads, was more affected by load configuration, extraction elements, and aircraft attitude, thereby resulting in greater inconsistency of load attitude during descent.

(2) Load Configuration:

(a) Load configuration had a significant effect on load attitude during drop and, consequently, on load survivability. Load pitch, roll, and yaw during drop were severely influenced by load center of gravity location. Best results were obtained when:

1. The vertical center of gravity of the load was as low as possible, consistent with requirements for placement of the energy dissipator.

2. The lateral center of gravity was centered.

3. The longitudinal center of gravity was 4 to 6 inches aft of the center of the platform to induce a slight nose-up attitude at impact.

4. Elements of the load were distributed evenly, longitudinally (Appendix VI.6). When this was not possible, best results were obtained if load concentrations were toward the center rather than the ends of the mass.

(b) Loads, varying in length from 8 feet to 14 feet, were dropped without difficulty (Appendix II). Because loads normally did not land in a flat attitude, loads overhanging the platform were not dropped. The maximum load height attempted during test was 61½ inches (M-170, 1/4-Ton Ambulance). No difficulties were encountered. Sixty-two inch height probes, used on loads during tests, did not strike the aircraft.

(c) Loads Nr 1, 2, 16, 18, and 48 lifted as they passed over the ramp (Appendix II). Maximum lift was 4 inches.

(3) Extraction Elements:

(a) The extraction force in all cases was applied to the load. Both the 15-foot and 22-foot extraction parachutes were used. The 22-foot extraction parachute provided more positive extraction, improved load stability, and reduced drop zone length requirements. An undesirable result, when employing the 15-foot extraction parachute, was the lateral roll of the load (Appendix VI.7). Loads Nr 46, 47, 50, 51, 52, 53, 54, 60, 66, 68, and 74, extracted by the 15-foot parachute, were so affected. In only two instances when using the 22-foot parachute did this occur; Load Nr 76 when the extraction point was placed off-center and Load Nr 77 when the lateral center of gravity was placed off-center.

(b) Loads rigged with the extraction point laterally on and approximately 3 to 6 inches above the center of gravity experienced a slight nose-up attitude. This provided the best load survivability (Appendix VI.8). However, when an extreme nose-up attitude at impact occurred, inertial forces continued so that a nose-down attitude developed after impact (Appendix VI.9). For

items of equipment that had a fixed extraction point, high above or far below the center of gravity, the longitudinal center of gravity of the load was shifted by use of a secondary load to counteract pitching forces (Appendices VI.6 and VI.9).

(c) When a dual extraction was made, the aft load (first to extract) did not attain normal extraction velocity. Consequently, load pitching was a greater problem on the first extracted load. The sequential extraction of more than two loads could not be accomplished with safety due to the method of final restraint of the loads (paragraph 2.4.3.1a).

(d) Two malfunctions of the pilot parachute occurred throughout test, one on Drop Nr 32 and the second on Drop Nr 55. The first malfunction was the result of attaching the pilot parachute bag to the extraction parachute bag without regard to directional relationship. Subsequently, bags were marked to insure proper attachment (Appendix VI.4). The second malfunction occurred when the 15-foot extraction parachute was first used. The safety tie on the pilot parachute did not break. This was due to the lesser weight of the 15-foot extraction parachute (22-foot extraction parachute had been used until this drop). The strength of the safety tie was decreased for subsequent drops. No other malfunction occurred.

(4) Aircraft Attitude:

Best results were obtained when the aircraft cargo ramp was level, cargo floor was horizontal to drop zone, power settings were equal and constant, flight was coordinated, airspeed was 80 to 90 KIAS, and wheel clearance was at 3 to 6 feet at moment of load extraction. When the ramp was placed below the horizontal position, platform pitching was initiated (Test Nr 2). The ramp was placed in the level position to aid in obtaining a desirable platform attitude.

c. Multiple Extractions:

Three missions were flown when two loads were extracted individually and no difficulties were encountered. Average time to position the extraction parachute in the pendulum ejector rack, prepare for extraction of the second load, and complete the normal sequence of operations check during flight was 6 minutes. Four dual extractions were made and no difficulties were encountered. Restraint procedures (except for final restraint of the load) outlined in TM 10-500-5 were used. Although the number of restraints and the point of attachment varied with the weight of

the loads, the restraint of the aft load to the forward load was less than the final restraint of the forward load. The emergency procedure of releasing sequential loads was tested. It required only the severance of the final restraints of the forward loads (Loads Nr 80 and 81, Appendix II).

d. Troop Exit:

LOLEX did not interfere with troop exit following drop of equipment. Following extraction of Load Nr 74, and after the aircraft had regained the required altitude, four paratroopers exited without difficulty.

e. Rigging, Derigging, and Recovery:

Rigging of loads was simple and rapid for qualified riggers and required no special training or equipment. Derigging required no special skills. There are no nonstandard components of the system that interfere with recovery or access to load items or equipment.

2.4.3.3 Aircraft control, flight safety, and crew procedures were determined and are included in Appendices IX and XI.

2.4.4 ANALYSIS

a. Criteria were met.

b. The modified parachute pendulum extraction system functioned satisfactorily throughout service tests. However, the rivets used to attach the locally fabricated hook (figure 2, Appendix X) were replaced during tests when the hook loosened.

2.5 TEST NR 5 - ACCURACY, RELIABILITY, AND EFFECTS OF TERRAIN

2.5.1 OBJECTIVE

a. Determine whether the accuracy and reliability of LOLEX are acceptable for delivery of Army supplies and equipment.

b. Determine effect of terrain on accuracy and reliability of LOLEX.

2.5.1.1 Criteria

a. LOLEX shall perform its mission within the limits of precision required for delivery of loads within 100 meters of the selected impact point (paragraph 14, Appendix III).

b. LOLEX shall perform its mission with maximum reliability under the following operating conditions:

(1) In ground winds from 0 - 30 knots.

(2) Delivery to be accomplished on varied terrain (paragraph 15, Appendix III).

2.5.2 METHOD

a. During conduct of Test Nr 4, impact areas were selected at varying distances from obstacles on the approach and climb-out paths for the extraction zone. Based on USAATA findings, all LOLEX drop zones selected were longer than the minimum field length required for STOL operations in the CV-2B aircraft.

b. Extractions were made on impact areas varying from prepared to unprepared surface; hard and soft surfaces; loose or sandy soil; level, inclined, and rolling terrain; and terrain covered with grass or short shrubs or bushes.

c. Drops were made in prevailing ground winds and on varied terrain available at the test sites.

d. Extraction distances were measured and recorded. Distances were measured from release point (a panel on the ground) to load impact and to load at rest.

e. Malfunctions and damage to system components or extracted loads were recorded and cause(s) therefor determined.

f. Results were recorded, studied, and evaluated.

2.5.3 RESULTS

a. During test, 77 loads impacted in a zone between extraction parachute release point plus 370 feet and extraction parachute release point plus 850 feet. The average impact was at 584 feet from the release point. This average included late pilot activation of the pendulum release, manual releases by the crew chief, and use of both the 22-foot and 15-foot extraction parachutes with and without pilot parachutes. Eighty-four per cent of the loads impacted between 450 and 700 feet beyond the release point. Loads impacting short of 450 feet were under 2,000 pounds. Loads impacting beyond 700 feet were over 3,000 pounds.

b. Load slide distance averaged 70 feet over varying types of terrain and impact surfaces. Impact surfaces (Appendix VI.10, 11, and 12) and average slide distances were as follows:

(1) On hard clay and sand, prepared landing strips, undulating, dry - 80 feet.

(2) On hard clay and sand, prepared landing strips, inclined, wet - 116 feet.

(3) On sandy soil, loose sand to a depth 8 - 10 inches, undulating, dry - [illegible]1 feet.

(4) On short dry grass, soft earth, dry, level - 37 feet.

(5) On area cleared of trees and stumps, but covered with tall grass and scrub oak up to 5-feet high and with 2-inch trucks, extremely rough terrain with hummocks to 1-foot high, dry, slight incline - 35 feet.

(6) On extremely rough terrain with high, dry grass and ruts to 1-foot deep, level, dry - 35 feet.

c. The average distance for the vehicle break-away system was 161 feet from impact to vehicle at rest.

d. The maximum level flight distance, airplane floor parallel to surface of drop zone (to insure impacting all loads in selected area), was 480 feet for single extractions and 615 feet for dual extractions.

e. The average distance required for the drop zone (from release point to load rest) without barriers was 654 feet for single loads, 789 feet for dual extraction, or 745 feet when using the break-away system used with vehicles.

f. The 1,600-foot minimum length drop zone, with 50-foot barriers on each end, as reported by USAATA (Appendix XI, page 15), was tested. When the parachute release point was placed 500 feet inside the 50-foot approach obstacle, the project test aviator experienced no difficulties. Drop height was 2 feet of aircraft wheel clearance. However, an aviator inexperienced with LOLEX, under the same conditions, dropped the load from a height of 30 feet of aircraft wheel clearance. When the parachute release point was placed 100 feet inside the 50-foot approach obstacle, no difficulties were encountered by either pilot. The extraction parachute was released

over the parachute release point while the aircraft was at an altitude of approximately 40 feet. The loads extracted at the selected impact point from a height of 4 feet when piloted by the project test aviator and from a height of 6 feet when piloted by an aviator inexperienced with LOLEX. The extraction parachute remained at the comparative height level with the aircraft during descent and exerted a straight-line pull.

g. All functions in the sequence of events, i. e., deployment ground distance, load extraction and descent ground distance, and load slide distance could be predicted with reasonable accuracy. However, pilot reaction in initiating the release was variable. The average release occurred at 125 feet beyond the release point, with a range spread of 50 feet short of the designated release point to 500 feet beyond the designated release point.

h. Two malfunctions (pilot parachutes) occurred during drop of 81 loads. Reasons for the malfunctions were determined and corrected. Malfunctions and damages to loads are recorded in Test Nr 4 and Appendix II.

i. Ground winds varied from 16 knots at a right angle to the direction of flight to a 10-knot head wind and 10-knot tail wind during testing at Fort Bragg (Appendix II). The extraction parachute, under all conditions, pulled relatively straight to the rear in line with the longitudinal axis of the aircraft. The only apparent effect of head wind or tail wind was on the total required drop zone distance for deployment and slide distance, decreasing with a head wind and increasing with a tail wind. The cross wind affected only slightly the last portion of the load slide. For aircraft control (cross wind correction using crab rather than slip technique), see Appendices IX and XI.

j. No ground preparation for the drop zone was required. Equipment used for the drop zone control was: one panel for the extraction parachute release "T," a second panel for a drop zone direction indicator, communication equipment, and recovery vehicles. Smoke was used, when requested by the aviator, to mark the drop zone and provide aviator orientation for direction of flight. On one occasion, no panels were used. The aviator, familiar with the general area and experienced in LOLEX operations, was requested to drop the load in a clump of brush that would be marked, short and over, with smoke. The load was delivered within 100 feet of the desired location (Load Nr 30, Appendix II).

2.5.4 ANALYSIS

Criteria were met with exception. Load survivability when employing LOLEX in ground winds in excess of 16 knots was not tested, although pilot's ability to fly the LOLEX sequence under wind conditions of 25 knots head wind to 30 knots at 90 degrees to a 15 knot tail wind was found satisfactory (Appendix XI).

2.6 TEST NR 6 - DROP ZONE REQUIREMENTS

2.6.1 OBJECTIVE

Determine the minimum drop zone dimensions, identification, and recovery equipment required for safe employment of LOLEX.

2.6.1.1 Criteria

Delivery to be accomplished on varied terrain without dependence on large drop zones, extensive ground preparation, or extensive prepositioned ground equipment (paragraph 15, Appendix III).

2.6.2 METHOD

Results of Tests Nr 4 and 5 were studied and evaluated.

2.6.3 RESULTS

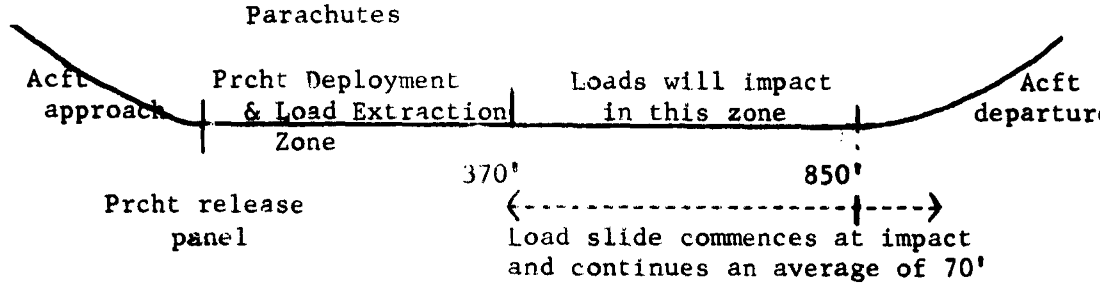
a. No ground preparation was required during tests. Marking of the drop zone was accomplished by use of panels and smoke. Panel emplacement required 5 minutes. When panels were used, the first panel indicated the parachute release point. The second panel, placed at 600 feet from the first panel, provided, in conjunction with the first panel, the desired direction of flight. The standard procedure of exact placement of the second panel (600 feet from the first panel) also served as a yardstick of distance for the aviator. Both panels were set at a 45-degree angle to the surface to provide depth perception and quicker and easier identification for the aviator. When visibility was decreased by terrain obstructions, pyrotechnics (smoke) were used for identification. The smoke was placed to the flank of the extraction parachute release point and to the same flank at the far end of the drop zone. The use of smoke, however, required caution in that it might obscure the drop zone. Smoke was therefore used in conjunction with the panels and used only for early identification of the drop zone and orientation for the aviator.

b. The ¼-ton truck was used to drag loads up to 1,500 pounds from the drop zone when the ground surface was a hard, smooth,

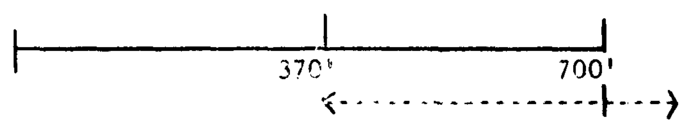
prepared surface. However, a 3/4-ton or 2½-ton truck was required to drag the same loads from unimproved surfaces or heavier loads from any surface. In general, clearance of the drop zone was the same as for standard air drop, except that no recovery (cargo) parachutes were involved.

c. LOLEX DROP ZONE DIMENSIONAL REQUIREMENTS

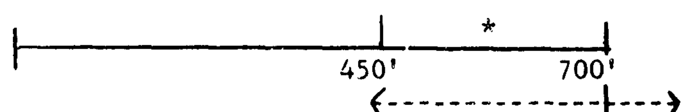
Single Load - When Using 22-Foot Extraction Parachute with Pilot Parachutes



For loads of 1,000 - 2,000 pounds

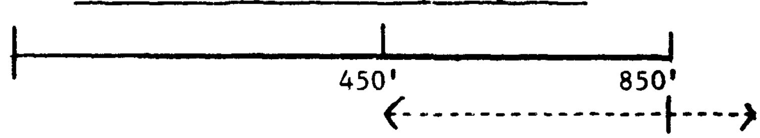


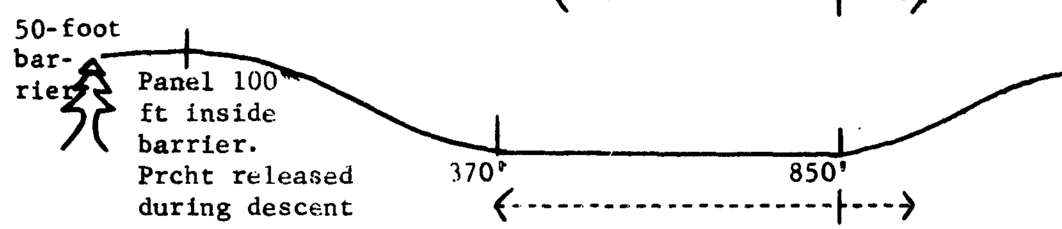
For loads of 2,000 - 3,000 pounds



*84% of all loads impacted in this zone

For loads of 3,000 - 4,000 pounds

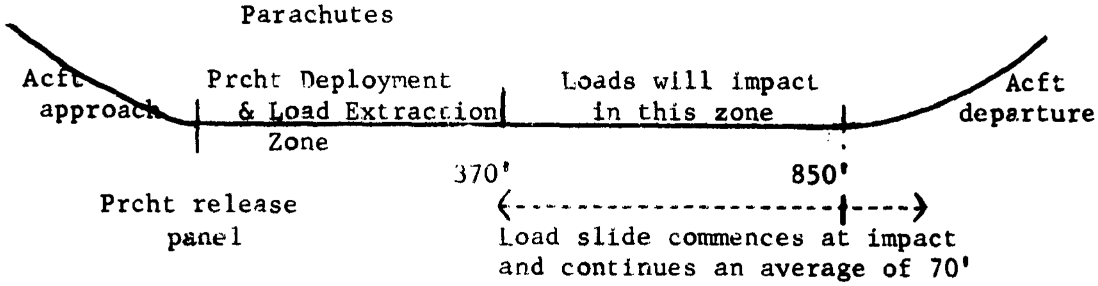




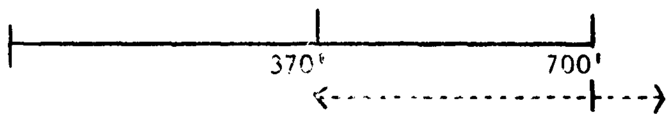
prepared surface. However, a 3/4-ton or 2½-ton truck was required to drag the same loads from unimproved surfaces or heavier loads from any surface. In general, clearance of the drop zone was the same as for standard air drop, except that no recovery (cargo) parachutes were involved.

c. LOLEX DROP ZONE DIMENSIONAL REQUIREMENTS

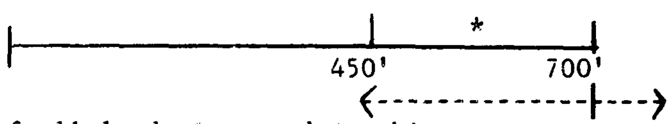
Single Load - When Using 22-Foot Extraction Parachute with Pilot Parachutes



For loads of 1,000 - 2,000 pounds

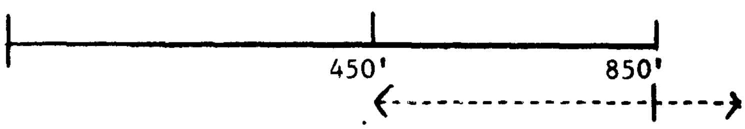


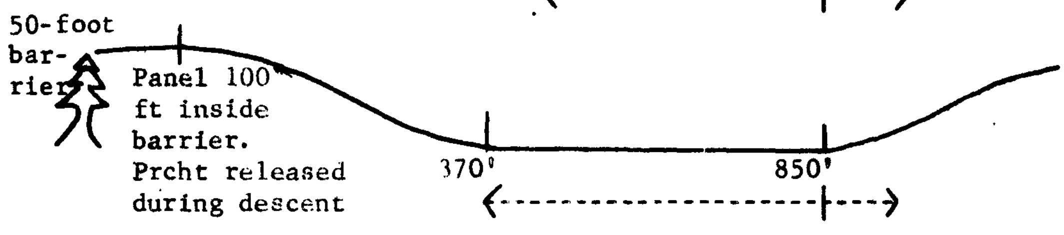
For loads of 2,000 - 3,000 pounds



*84% of all loads impacted in this zone

For loads of 3,000 - 4,000 pounds





(1) Aircraft approach and descent corridor, free of air space obstructions, requires a minimum length of 500 feet per 50 feet of barrier height above delivery area surface and 135 feet wide. Under tactical conditions, when drop zone length does not permit a low angle approach, the release point should be placed 100 feet inside the approach barrier. Parachute deployment occurs during final descent of the aircraft. This procedure is also recommended for use on drop zones covered with brush.

(2) The impact and slide area must be free of air space obstructions and requires such surface preparation (30 feet wide) as may be necessary for load survivability. The area must be free of large rocks, trees, stumps, holes, mounds, or other protrusions which might demolish the load if struck at impact or during the first portion of slide.

(3) Aircraft departure and climb-out corridor, which begins immediately after the load has cleared the aircraft, must be free of air space obstruction and requires a minimum length of 500 feet per 50 feet of barrier height above delivery area surface and 135 feet wide.

(4) The load slide area length may vary from 35 feet for soft or rough surface to 116 feet for prepared, hard, wet surface. Requirements for preparation are as in paragraph (2), above.

(5) For break-away system, 161 feet must be used in lieu of the slide distance.

(6) For dual extractions, 135 feet must be added to impact and slide area requirements of first load.

2.6.4 ANALYSIS

a. Criteria were met.

b. Drop zone length requirements were determined only from aircraft performance on test day conditions at Fort Bragg, North Carolina, and would vary significantly with changes in gross weight, air speed, and altitude. Drop zone length required for successful climb-out following an engine failure during the LOLEX sequence was not determined.

2.7 <u>TEST NR 7 - RESTRICTIONS</u>

2.7.1 OBJECTIVE

Determine restrictions on the use of LOLEX to include:

a. Type, weight, height, width, and center of gravity of the extracted load.

b. Standard air drop extraction and air unloading systems as modified.

c. Weather.

d. Flight safety.

2.7.1.1 Criteria

a. LOLEX shall permit the delivery of single loads from 1,000 to 4,000 pounds (paragraph 16, Appendix III).

b. LOLEX shall permit the delivery of all loads of a size within the permissible load envelope for standard air drop from CV-2B aircraft (paragraph 17, Appendix III).

c. LOLEX shall not reduce the all-weather capability of CV-2B aircraft (paragraph 18, Appendix III).

d. LOLEX shall facilitate the consecutive delivery of personnel without obstruction from system components (paragraph 19, Appendix III).

2.7.2 METHOD

a. Data developed in Tests Nr 2 through 6 were studied to determine restrictions on LOLEX in areas outlined in 2.7.1, above.

b. Results were recorded, studied, and evaluated.

2.7.3 RESULTS

a. The load weight range during test was 920 to 4,130 pounds, with platform lengths from 8 to 14 feet, respectively. All platform widths were 70 inches to preclude shifting and a resultant potential lodging of the load in the aircraft during extraction. Loads Nr 1, 2, 16, 18, and 48 lifted a maximum of 4 inches as they passed over the ramp. These loads were in the lightweight category under 1,500 pounds and did not exceed 55 inches in height.

b. The maximum height of loads during tests was 61½ inches (M-170, ¼-Ton Ambulance). No difficulties were experienced.

Height probes up to 62 inches placed on loads did not strike the aircraft.

c. The location of the center of gravity had a very significant effect on load attitude. When the lateral center of gravity was placed off-center, a lateral roll of the load resulted (Appendix VI.7). The longitudinal center of gravity affected load pitch (Appendix VI.8). A high center of gravity caused the load to separate from the platform at impact (Loads Nr 4 and 11, Appendix II).

d. The location of the extraction point affected load attitude. The force of the extraction parachute exerted its pull from the extraction point on the load around the load center of gravity, thereby affecting load attitude (Appendix VI.8).

e. The type of loads varied from C-rations to an M-151, ¼-Ton Vehicle with radio mounted therein (Appendix II). Loads were not restricted by type.

f. The standard air drop system was modified as described in Test Nr 4.

g. Ground winds had no adverse effects on delivery of loads except as affects pilot's ability to fly in the crab attitude (Appendix XI). LOLEX did not reduce the all-weather capability of CV-2B aircraft.

h. Flight safety is discussed in Test Nr 2 and Appendix IX.

i. There are no restrictions to consecutive delivery of personnel. After delivery of a load, and after the aircraft had regained the required altitude for personnel jumps, four parachutists exited without difficulty (Load Nr 74, Appendix II).

j. Due to platform attitude at moment of impact, LOLEX was restricted to no overhang of the load from the platform, either fore or aft.

2.7.4 ANALYSIS

a. Criteria were met.

b. LOLEX meets the load weight range criteria of 1,000 to 4,000 pounds. However, certain qualifications must apply. Lift of the load as it passes over the ramp, whether caused by air turbulence, aircraft control, or load weight, must be considered. To remain within space limitations specified in TM 10-500-5, the maximum lift (4 inches) experienced in tests should be considered. Until more definitive engineer data is available, the permissible load

height for the load weight range of 1,000 - 2,000 pounds should be limited to 50 inches in height unless it has been tested by an authorized U. S. Army test agency. In addition, the height of any load should not exceed 60 inches unless it has been tested by an authorized U. S. Army test agency. Height limit exceedence would become a risk consideration.

c. The 70-inch width of the platform should be mandatory to prevent shifting of the platform in the aircraft. A narrower platform presents the potential problem of shifting and resultant lodging in the aircraft which could result in an uncontrollable flight condition. The load should be 1-inch inboard from the sides of the platform and should have no longitudinal or lateral overhang, unless specifically tested by an authorized U. S. Army test agency.

2.8 TEST NR 8 - SAFETY CONFIRMATION

2.8.1 OBJECTIVE

Determine if LOLEX presents unacceptable safety hazards.

2.8.1.1 Criteria

a. LOLEX shall be such that the aircraft, associated equipment, and using personnel are exposed to minimum hazard (paragraph 20, Appendix III).

b. The design of LOLEX shall be such that visual inspection for operational readiness is possible at any time prior to use (paragraph 21, Appendix III).

2.8.2 METHOD

a. During the conduct of all phases of the test, continuous review was made of test conditions and of flight, extraction, and rigging procedures to identify problem areas as they pertain to safety in the use of LOLEX. Problem areas were studied with the purpose of eliminating or minimizing the safety hazards.

b. Data pertaining to the safety confirmation required by USATECOM Regulation 385-7 were recorded.

c. Data were evaluated and results recorded.

2.8.3 RESULTS

a. There are no known safety hazards in the employment of LOLEX provided:

(1) Final restraint of the load is accomplished as described in Test Nr 4.

(2) The pendulum release system is modified as described in Test Nr 4 and Appendix X.

(3) The safety line is installed as described in Test Nr 4.

(4) Load configuration is as described in Test Nr 4 and Test Nr 7.

(5) Flight safety parameters and operational procedures determined in Test Nr 2 are employed.

(6) Aircraft control, flight safety, and crew procedures as described in Appendices IX and XI are used.

b. There is no special training required for LOLEX. However, a dropmaster, in addition to the crew chief, must be aboard the aircraft (Appendix XI).

c. The arrangement of the extraction system and tiedown used with LOLEX permits visual inspection of the system.

2.8.4 ANALYSIS

Criteria were met.

2.9 TEST NR 9 - FINAL LOLEX SYSTEM, DEFINED

2.9.1 OBJECTIVE

Determine, by study, the concise definition of the optimum LOLEX system as evolved during Tests Nr 1 through 8.

2.9.2 METHOD

Results of Tests Nr 1 through 8 were evaluated.

2.9.3 RESULTS

a. LOLEX is an adaptation of the standard air drop system. Extraction of the load is accomplished while the aircraft with landing gear down, cargo door open, and ramp level is flying close to the ground (3 - 6-feet wheel height) and at reduced speed (80-90 knots), thereby eliminating the need for recovery (cargo)

parachutes. An extraction parachute activated by two pilot parachutes extracts the load, stabilizes it during descent, and retards its forward momentum (Appendix VI.13).

b. LOLEX for CV-2B aircraft consists of the following standard components:

(1) Combat expendable air drop platforms, 70-inch width, in lengths of 8 to 14 feet.

(2) Paperboard honeycomb energy dissipator.

(3) Tiedown straps and load binders.

(4) Cargo slings and clevises.

(5) Ringslot extraction parachute, 22-foot.

(6) Extraction line, 60-foot, 6-ply.

(7) Pilot parachute, cargo type, 5' 8" diameter.

(8) Pilot parachute, personnel type, 2' 2" diameter.

c. A nonstandard, locally fabricated, pilot parachute bag was incorporated into LOLEX (Test Nr 4 and Appendix VI.3).

d. The standard CV-2B aircraft is used. However, the pendulum release system was modified (Test Nr 4, Appendix VI.2, and Appendix X).

APPENDIX I - TEST DIRECTIVE

HEADQUARTERS
U. S. ARMY TEST AND EVALUATION COMMAND
Aberdeen Proving Ground, Maryland 21005

C O P Y

AMSTE-BG 29 Nov 1963

SUBJECT: Directive for Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft. USATECOM Project Nr. 4-4-7475.

TO: President, U. S. Army Airborne, Electronics and Special Warfare Board, Fort Bragg, North Carolina 28307
Commanding Officer, Yuma Proving Ground, Yuma, Arizona 85364
Commanding Officer, U. S. Army Aviation Test Board, Fort Rucker, Alabama 36362
Commanding Officer, U. S. Army Aviation Test Activity Edwards Air Force Base, California 93523

1. Reference letter, AMCRD-DM-E, Hq, USAMC, 18 November 1963, subject: New Air Delivery Techniques for CV-2B Airplane (Incl 1).

2. Description of Material: See paragraph 2 of inclosure 1 to reference.

3. Background: See reference.

4. Test Objective: The objective of this project is to determine suitability of LOLEX as a standard U. S. Army system for air delivery of cargo. Special consideration should be given both to safety and reliability with particular attention on:

a. Aircraft control.

b. Stress upon loads.

c. Rigging procedures.

d. Pilot techniques.

5. Special Instructions:

a. USAAE&SW Board is responsible for coordinating all LOLEX test efforts and is executive agency for project.

b. Yuma Proving Ground is designated a supporting test agency with primary interest in ...ineering portion of test as pertains to the air delivery systems used and loads delivered.

c. USAATA is designated a supporting test agency with primary interest in engineering portion of test as pertains to the aircraft structure and stability and control.

d. USAAvnTBd is designated a supporting test agency with primary interest in service test of LOLEX as pertains to operation of the aircraft and development of aircrew procedures.

e. TEAMS Project-Task numbers are assigned as follows:

(1) USAAE&SW Board - Project-Task Nr. 4-4-7475-01.

(2) Yuma Proving Ground - Project-Task Nr. 4-4-7475-02.

(3) USAATA - Project-Task Nr. 4-4-7475-03.

(4) USAAvnTBd - Project-Task Nr. 4-4-7475-04.

6. Coordination: In addition to addressees above, test plan will be coordinated by USAAE&SW Board with Commanding Officer, Tenth (10th) Air Transport Brigade, Ft Benning, Georgia; Commandant, USA Quartermaster School (Airborne Department); Air Delivery Equipment Division, Natick Laboratories; USABAAR, Ft Rucker, Alabama; USA Aviation School; and Airborne-Air Mobility Department, USA Infantry School; and appropriate CDC agencies.

7. Test Plans and Reports:

a. Test Plans: Consolidated plan of test will be submitted by USAAE&SW Board to this headquarters not later than 18 December 1963. Plan should include list of agencies with whom coordination was effected and comments from coordinating agencies which were not incorporated in plan with reasons therefore.

AMSTE-BG 29 Nov 1963

SUBJECT: Directive for Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft. USATECOM Project Nr. 4-4-7475.

Special requirements for conduct of test should be forwarded with plan of test as requested in paragraph 5 of reference.

b. Test Reports: Upon test completion a final formal report will be prepared and distributed in accordance with attached distribution list (Incl 2) and USATECOM Regulation 705-2.

FOR THE COMMANDER:

2 Incl
as

/s/ Earl A. Hicks, Jr
/t/ EARL A. HICKS, JR
Lt. Col. Arty
Asst Admin Officer

Copies furnished:
CG, USA Natick Labs
(ATTN: Aerial Delivery Equip Div)
CO, Tenth (10th) Air Transport Brigade
Commandant, USA Quartermaster School
Commandant, USA Infantry School
Commandant, USA Aviation School
Director, USABAAR

APPENDIX II - TEST DATA

Loads are not listed numerically on the test data sheets but rather by test conditions. For appropriate load number, use following reference:

Load Nr	Page Nr	Load Nr	Page Nr
1, 2, 3, 4, 5	II.2	44, 45	II.9
6, 7	II.3	46, 47	II.18
8, 9	II.5	48, 49	II.20
10, 11, 12	II.3	50	II.18
13, 14	II.4	51	II.19
15, 16	II.5	52	II.16
17	II.6	53, 54	II.17
18, 19, 20, 21	II.8	55	II.29
22, 23, 24	II.10	56, 57, 58, 59	II.13
25, 26	II.9	60, 61	II.19
27, 28	II.21	62, 63	II.20
29, 30	II.22	64, 65	II.16
31	II.23	66, 67	II.27
32	II.29	68, 69	II.28
33	II.23	70, 71, 72	II.12
34, 35	II.24	73, 74	II.11
36	II.23	75	II.12
37, 38, 39	II.25	76, 77, 78	II.14
40	II.26	79	II.15
41, 42	II.6	80, 81	II.30
43	II.7		

SECTION I: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - Sicily; landing strip hard clay & sand, dry.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
1	Rations	1175	24	70x96	10@ 3:00	+80	230	550	620	+20	6	85	15	Nose Down	Intact Good	Load raised 2 inches from ramp.
2	Sim Ammo -boxes-	1250	36	70x96	10@ 3:00	+100	220	550	615	+15	5	85	15	45 Nose Up	Intact Good	Load raised 1 inch from ramp.
3	40 5-Gal Water Cans	2335	26	70x96	8@ 3:00	+350	560	850	885	+285	12	80	15	Nose Up	Separated from platform. 6 cans leaked after drop. Add paperboard honeycomb.	
4	4 55-Gal Drums/Water	2360	42	70x96	5@ 3:00	+200	325	835	920	+320	7	85	15	70 Nose Up	Separation from platform. Drums dented - no leaks. CG too high. Malfunction. Manual release used.	
5	M-274 Mule	1040	39	70x96	5@ 3:00	+75	215	545	580	-20	5	85	15	35 Nose Up	Intact Good	

SECTION I (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
6	M100 Tlr w/Sim Ammo	1790	51	70x96	6@ 2:00	+150	300	640	695	+95	7	90	15	5 Nose Down	Turned over. No damage. Rig tlr upside down for next drop.	
7	PAP	2674	25	70x144	5@ 3:00	+175	325	660	745	+145	6	85	15	5 Nose Down	Intact Good	Height probe - OK at 62"
10	M151 ¼-Ton	2625	58	70x120	8@ 12:00	+300	450	786	960	+160	2	85	15	Flat	Antenna Mount Bent. Veh-OK	51' Skid) Break-129' Roll) away Remove all side mounts on vehicles.
11	3 55-Gal Drums/Water	1805	43	70x96	10@ 12:00	+75	220	550	600	-	3	85	15	25 Nose Up	Separation from platform. Drums OK. Rig on break-away skid.	
12	M416 Tlr w/Sim Ammo	1240	42	70x96	12@ 3:00	+350	460	790	820	+220	5	85	15	Flat	Tail Gate Slightly Bent	Paperboard honey-comb lost before impact.

SECTION I (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
13	M170 Amb	3045	61½	70x144	8@ 2:00	+125	315	660	872		12	90	7	20 Nose Up	Good	Break-away system. 65' skid. 147' roll.
14	4.2 Mortar w/Sim Ammo	1040	26	70x96	5@ 6:00	+175	325	630	675	+75	5	80	15	3 Nose Up	Intact Good	

SECTION II: Conditions: Extraction parachute - 22 foot w/pilot chutes. Impact area - Sicily - sandy, loose to a depth of 8-10 inches. Level area. Dry.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
8	Rations	1175	24	70x96	6@ 3:00	≁100	205	530	540	60	12	85	15	30 Nose Down	Intact Good	Load rotating [illegible] level to nose [illegible]
9	40 5-Gal Can/Water	2330	26	70x96	6@ 6:00	≁100	250	545	610	≁10	3	78	15	30 Nose Down	Intact Good	New rigging includes paperboard honeycomb between rows.
15	M274 Mule	1000	38	70x96	3@ 3:00	≁150	270	585	600		6	82	15	40 Nose Up	Intact Good	Location of extr point induces nose up attitude.
16	M416 Tlr w/ Sim Ammo	1160	42	70x96	4@ 2:00	≁100	250	563	590	-10	4	80	15	Flat	Intact Good	Tlr rigged upside down. Load raised from ramp 4 inches at tip-off. Height probe at 62" OK.

SECTION II (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
17	3 55-Gal Drums/Water	1800	43	70x96	7@ [illegible]:00	[illegible]75	[illegible]10	515	527	33	5	8[illegible]	15	50 Nose Up- Extr Pt [illegible]	Separation Good	Cannot restrain drums to prevent separation from platform at impact.
41	Sim Ammo on Break-away skid	1490	25	70x96	16@ 3:00	[illegible]00	350	605	675	[illegible]75	8	8[illegible]	15	[illegible]0 Nose Down	Good	Skid broke away at 675[illegible]. Extr point midway.
42	M151 ¼ Ton	2625	58	70x144	12@ 3:00	[illegible]350	525	840	1105	[illegible]205	3	83	15	30 Nose Up	Good	Break-away @ 900 feet.

SECTION II (continued)

Load Nr	43
Description	M170 Amb
Weight (Pounds)	3030
Height (Inches)	61½
Platform Size (Inches)	70x144
Wind Speed (Knots) & Direction (Vs Flight Path)	9@ 5:00
"T" to Prcht Release (Feet)	+325
"T" to Full Deployment (Feet)	500
"T" to Impact (Feet)	900
"T" to Load Rest (Feet)	1000
Distance from Pre-selected Area (Feet)	+100
Aircraft Wheel Height at Extraction (Feet)	4
Air Speed (Knots)	90
Flap Setting (Degrees)	7
Platform Attitude at Impact (Degrees)	30 Nose Up
Condition of Load	Good
Remarks	Not a complete breakaway. Too much paperboard honey-comb energy dissipator. Crushing stroke too short for good breakaway. Reduce amount of paperboard honeycomb.

SECTION III: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact areas - Inverness Strip. Hard sand and clay. Level. Wet. Barrier approach - 40 feet high. "T" - 560 feet from barrier. Overall - 2,600 feet.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
18	Rations	1175	26	70x96	3@ 1:00	+75	200	525	605	+5	10	85	15	Flat	Intact Good	Load raised 2 inches from ramp.
19	PAP	2560	24	70x144	Calm	+200	350	650	835	+235	1	80	15	5 Nose Up	Intact Good	
20	3 55-Gal Drums/Water	1800	43	70x96	Calm	+200	300	605	670	+70	1	80	15	10 Nose Down	Separation Good	Extr point 10 inches above bottom.
21	M416 Tlr w/Sim Ammo	1160	42	70x96	Calm	+450	550	925	1060	+460	3	95	7	Flat	Intact Good	Non-linear tactical approach.

SECTION IV: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - TAC Strip #13. Hard clay and sand. Dry. Barrier approach - 40' barrier on each end. Overall length - 1,600 feet.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
25	Rations	1175	26	70x96	Calm	+160	300	600	610	+10	30	78	15	Flat	Intact Minor Crush-ing	"T" - 500' from tree line.
26	M416 Tlr w/ Sim Ammo	1160	42	70x96	Calm	+125	280	605	705	+105	2	85	15	Flat	Intact Good	"T" - 500' from tree line.
44	4.2 Mortar w/Sim Ammo	1040	24	70x96	4@ 2:00	+100	210	500	575	-25	4	75	15	Flat	Intact Good	"T" - 100' from tree line. Extr chute re-leased at altitude.
45	PAP	2580	26	70x144	5@ 2:00	+100	230	530	620	+20	6	80	15	Flat	Intact Good	Same as 44. Height probe OK at 62".

SECTION V: Conditions: Extraction parachute 22-foot w/pilot chutes. Impact area Sicily. Landing strip hard clay and sand. Dry. Level.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
22	4.2 Mortar w/Sim Ammo	1040	26	70x96	2@ 12:00	450	180	510	585	15	[illegible]	85	15	10 Nose Down	Intact Good	Rotated [illegible] nose down.
23	M274 Mule	1000	40	70x96	DUAL	EXTRACTION		905	920		[illegible]			5 Nose Down	Broken axle	Rotated from 45 nose up. Transient forces caused increase in altitude.
24	Rations	3970	33	70x168	4@ 7:00	450	180	525	805	4205	4	90	7	10 Nose Up	Intact Good	

SECTION VI: Conditions: Extraction parachute - 15-foot w/o pilot chutes. Impact area - Sicily. "T" in sand. Load impact area hard and dry. Area rough to impact point.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
73	M-274 Mule	1000	[illegible]	70x96	Calm	+50	270	585	615	+15	5	80	15	80 Nose Up	Intact Good	Height prob[illegible] at 62".
74	M100 Tlr w/Sim Ammo	1160	52	70x96	Calm	+50	350	690	820	+220	4	85	15	10 Nose Down. Right Front	Intact Good	Load followed by 4 jumpers. Height probe OK at 62".

SECTION VII: Conditions: Extraction parachute - 22-foot w/o pilot chutes. Impact area - Sicily. "T" in sand. Load impact area hard and dry. Area rough to impact point.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
70	4.2 Mortar w/Sim Ammo	1040	26	70x96	Calm	/50	300	600	660	/60	4	[illegible]	15	10 Nose Up	Intact Good	Extr chutes [illegible] on ground in [illegible]tion of flight. Height probe OK at 62".
71	Rations	1175	26	70x96	Calm	/100	350	652	705	/105	/	80	15	30 Nose Down	Intact Good	
72	Sim Ammo -boxes	1250	25	70x96	Calm	·50	150	450	510	·90	4	80	15	45 Nose Up	Intact Good	Extr point high. Height probe OK at 62".
75	4.2 Mortar w/Sim Ammo	1040	26	70x96	3@ 2:00	·50	200	490	530	-70	3	85	15	5 Nose Up	Intact Good	Extr point off center.

SECTION VIII: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - Sicily. "T" in sand. 500 feet of impact area was hard clay and sand. Dry.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
56	M274 Mule	1000	38	70x96	4@ 3:00	+150	300	590	630	+30	4	77	15	60 Nose Up	Intact Good	Height prob- OK at 62".
57	Sealdbin Container w/Water	4130	43	70x96	6@ 3:00	+150	300	640	780	+180	3	90	7	5 Nose Down	Good	Break-away system functioned at 690'.
58	Sim Ammo -boxes-	1980	43	70x96	7@ 1:00	+50	200	510	600		4	78	15	40 Nose Down	Good	Platform broke. 1st of dual load too near ramp.
					DUAL LOAD - SINGLE EXTRACTION											
59	M100 Tlr w/Sim Ammo	1160	42	70x96	6@ 2:00	+300			950		3	80	15	10 Nose Up	Intact Good	2nd of dual load. Pilot error on re-lease.

SECTION VIII (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
76	Sim Ammo -boxes	1250	25	70x96	5@ 2:00	/50	200	490	510	-90	10	80	15	30 Nose Down Right Cor-ner	Intact Good	Load rigged with extr point 6 inches off center.
77	Sim Ammo -boxes	1250	25	70x96	5@ 2:00	/50	200	500	540	-60	5	80	15	20 Nose Down Right Cor-ner	Intact Good	Load rigged with lateral CG 6 inches off center.
78	Rations	1250	34	70x96	6@ 2:00	/50	150	415	435	165	5	70	15	88 Nose Up	Good	Platform broke. Extr point at top of load.

Remarks	Extr point at bottom of load.
Condition of Load	Intact Good
Platform Attitude at Impact (Degrees)	45 Nose Down
Flap Setting (Degrees)	15
Air Speed (Knots)	78
Aircraft Wheel Height at Extraction (Feet)	5
Distance from Pre-selected Area (Feet)	9[illegible]
"T" to Load Rest (Feet)	506
"T" to Impact (Feet)	500
"T" to Full Deployment (Feet)	[illegible]00
"T" to Prcht Release (Feet)	[illegible]100
Wind Speed (Knots) & Direction (Vs Flight Path)	9@ 2[illegible]00
Platform Size (Inches)	70×96
Height (Inches)	3[illegible]
Weight (Pounds)	1 50[illegible]
Description	Rations
Load Nr	79

SECTION IX: Conditions: Extraction parachute - 15 and 22-foot without pilot chutes. See Remarks. Impact area - Sicily. "T" in sand. 500 feet impact area was hard clay and sand mixture. Level. Dry.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
64	40 5 Gal Water Cans	2345	27	70x96	2@ 2:00	+50	300	610	700	+100	[illegible]	8[illegible]	15	10 Nose Down	Intact Good	[illegible] w/o pilot
65	PAP	2560	26	70x144	2@ 2:00	+100	350	650	750	+150	3	80	15	Flat	Intact Good	22' w/o pilot
52	Sim Ammo boxes Break-away Skid	1490	25	70x96	6@ 6:00	+25	350	690	760	+160	7	90	7	5 Nose Up. Right Side Ex-treme	Good	15' w/o pilot. Break-away occurred at 700'.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
53	Sim Ammo -boxes-	920	25	70x96	3@ 2:00	+100	330	630	700	+100	4	80	15	5 Nose Up. Right Side	Intact Good	15' w/o pilot
54	Sim Ammo -boxes-	920	25	70x96	5@ 2:00	+25	280	594	660	+60	4	82	15	5 Nose Down. Right Side Ex-treme	Intact Good	15' w/o pilot. Extreme right side tilt broke platform.

SECTION X: Conditions: Extraction parachute - 15-foot w/pilot chutes. Impact area · Falcon Strip. Hard sand and clay. Slopes 5 degrees uphill in direction used. Wet.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
46	Sim Ammo boxes-	920	25	70x96	3@ 1:30	≠50	225	510	615	≠15	2	75	15	Right Corner 10 Nose Down	Good	Height probe [illegible] ar 62".
47	Sim Ammo boxes-	920	25	70x96	3@ 1:30	≠250	400	700	790	≠190	12	78	15	Right Side Impact Slight	Good	23 minutes turn-around time from Pope AFB.
50	M416 Tlr w/Sim Ammo	1160	42	70x96	5@ 12:00	≠100	300	600	715	≠115	8	80	15	Right Side Impact Slight	Good	Chute did not touch ground.

SECTION X (continued)

Load Nr.	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
51	M100 Tlr w/Sim Ammo	1240	42	70x96	5@ 6:00	+100	360	670	760	+160	8	130	15	5 Nose Up Slight Right Side	Good	25 minutes turn-around time from Pope AFB.
60	Sim Ammo -boxes	920	25	70x96	4@ 2:00	+125	300	615	740	+140	2	85	7	Slight Right Side	Good	Showing definite pattern of platform landing on right side. 1st load of dual extraction.
					DUAL	EXTRACTION										
61	Sim Ammo -boxes	920	25	70x96				1010	1160		2			5 Nose Up	Good	2nd load of dual extraction.

SECTION XI: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - Falcon Strip. Hard sand and clay. Slopes 5 degrees uphill in direction used. Dry.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
48	4.2 Mortar w/Sim Ammo	1040	24	70x96	4@ 2:00	≠50	200	520	600	-	4	80	15	5 Nose Up	Intact Good	Load raised from ramp 2 inches.
					DUAL	EXTRACTION										
49	M274 Mule	1000	38	70x96				940	980		7			45 Nose Up	Intact Good	Load raised from ramp 2 inches.
62	Rations	3970	25	70x168	6@ 2:00	≠150	275	630	800	≠200	4	90	15	30 Nose Up	Intact Good	Height probes OK at 62".
63	M151, ¼ Ton	2625	58	70x132	7@ 2:00	≠100	230	535	600		3	80	15	15 Nose Up	Good	One tape did not break. Too much energy dissipator.

SECTION XII: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - MacKall. Grass, soft earth, dry, level.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
27	Sim Ammo -boxes	2140	37	70x96	7@ 6:00	+100	270	635	665	+65	15	95	7	20 Nose Down		Load separated from platform. One of 15 boxes broken. This was first of dual load in acft at arm #452. Too close to ramp to generate sufficient extr speed over the ramp. In such cases extr point should be high.
					DUAL	LOAD	- SINGLE	EXTRACTION								
28	Water Cans	2345	27	70x96	7@ 6:00	+100	250	550	595	-5	10	80	15	5 Nose Up	Intact Good	6 minutes required to rig 2nd load during flight.

SECTION XII (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
29	M151 ¼ Ton	2625	58	70x132	7@ 5:00	1150	260	560	7[illegible]5	[illegible]75	[illegible]	80	15	Flat	Good	Break away, slide 165 [illegible]. Rigged load had been hauled on semi-tlr 45 miles. Caused 2 inches of crushing of PBH. Tiedowns needed retightening.
30	4.2 Mortar w/Sim Ammo	1040	24	70x96	7@ 5:00					100	15	78	15	15 Nose Down	Intact Good	No "T" used. While airborne, pilot was requested to put load in clump of trees marked w/ smoke.

SECTION XIII: Conditions: 22 foot w/pilot chutes. Impact area - MacKall. Grass, soft earth, dry, level.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
31	M416 Tlr w/Sim Ammo	1160	52	70x96	5@ 5:00	+120	270	585	640	+40	6	80	15	5 Nose Down	Intact Good	PBH had 2 inches of crushing from transport on semi-tlr. Tiedowns required retightening prior to drop.
33	M170 Amb	3030	61½	70x144	Calm	+100	250	660	870	+70	16	80	15	20 Nose Up	Good	Break-away. 10' slide. 200' roll.
36	PAP	2560	26	70x132	3@ 2:00	+500	660	980	1030		2	80	15	10 Nose Up	Intact Good	Manual release when automatic release failed.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
34	Rations	117[illegible]	26	70x96	3@ 2:00	[illegible]25	150	440	452	-148	1	80	15	20 Nose Down	Intact Good	This was first [illegible] dual load. [illegible] close to ramp to generate maximum extr speed over ramp. Elevate extr point.
				DUAL LOAD -- SINGLE EXTRACTION												
35	M274 Mule	1000	31	70x96	3@ 2:00	-25	90	435	465	-135	4	95	7	30 Nose Up	Intact Good	6 minutes required to rig 2nd load during flight. Tactical approach tree-top level. DZ marked with smoke.

SECTION XIV: Conditions: Extraction parachute - 22-foot w/pilot chutes. Impact area - Luzon. Extremely rough, uneven ground. Covered with scrub oak 3-6' tall.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
37	Rations	1175	26	70x96	7@ 1:00	+170	300	595	600	-	8	80	15	Slight Nose Up	Intact Good	Height probe Cr [illegible] 62".
38	Rations	3970	33	70x168	5@ 1:00	+75	230	520	590	-10	12	75	15	Flat	Intact Good	Extr point 1/3 distance from bottom.
39	3 55-Gal Drums/Water	1800	46	70x96	5@ 5:00	-40	50	370	385	-115	7	85	15	Slight Nose Down	Good	Drums in A-22 container rigged to platform for breakaway.

SECTION XIV (continued)

Remarks	Cans separat[illegible] platform. Extr point was below CG - too low. Chutes drag through brush. Recommend releasing extr chutes during descent.
Condition of Load	Good
Platform Attitude at Impact (Degrees)	20 Nose Down
Flap Setting (Degrees)	15
Air Speed (Knots)	80
Aircraft Wheel Height at Extraction (Feet)	9
Distance from Pre-selected Area (Feet)	-50
"T" to Load Rest (Feet)	550
"T" to Impact (Feet)	550
"T" to Full Deployment (Feet)	250
"T" to Prcht Release (Feet)	+125
Wind Speed (Knots) & Direction (Vs Flight Path)	10@ 5:00
Platform Size (Inches)	70x96
Height (Inches)	27
Weight (Pounds)	2345
Description	Water Cans
Load Nr	40

SECTION XV: Conditions: Impact area - Luzon. Extremely rough uneven ground covered with tall grass.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
66	Sim Ammo -boxes-	920	25	70x96	4@ 3:00	-	125	430	460	-140	4	80	15	10 Nose Up. Right Side	Intact Good	15-foot extr chute w/pilot chutes. Height probe OK.
67	Water Cans	2345	27	70x96	2@ 3:00	+50	200	520	560	-40	13	80	15	45 Nose Down	7 Cans Leaking	Extr point floating. Acft extreme nose up attitude. Load left acft at 45 nose up, rotated to 45 nose down. 22-foot extr chute w/pilot chutes.

SECTION XV (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
68	Sim Ammo -boxes-	1495	26	70x96	Calm	/50	150	485	545	55	2	85	15	5 Nos Down, Right Side	Good	Load was rigg [illegible] break-away. Separation at 515 [illegible] 15-foot extr chute w/ pilot chute. Load rotating nose down.
69	Rations	2000	37	70x96	Calm	/150	320	650	710	/110	8	85	15	Slight Nose Up	Intact Good	22-foot extr chute w/pilot chutes.

SECTION XVI: Conditions: Malfunctions emergency procedures used.

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
55	Sim Ammo boxes	1430	34	70x96	4@ 2:00				1380		50	80	15			15' extr chute w/ pilot chutes fell on ramp. Safety tie on pilot chute did not break. Safety tie changed for subsequent drops.
32	3 55 Gal Drums/Water	1800	46	70x96	5@ 4:00				1600 Approx		125	80	15			22' extr chute w/ pilot chutes fell on ramp. Pilot chute bag attached wrong. Riggers instructed. Bags marked to preclude error.

SECTION XVI (continued)

Load Nr	Description	Weight (Pounds)	Height (Inches)	Platform Size (Inches)	Wind Speed (Knots) & Direction (Vs Flight Path)	"T" to Prcht Release (Feet)	"T" to Full Deployment (Feet)	"T" to Impact (Feet)	"T" to Load Rest (Feet)	Distance from Pre-selected Area (Feet)	Aircraft Wheel Height at Extraction (Feet)	Air Speed (Knots)	Flap Setting (Degrees)	Platform Attitude at Impact (Degrees)	Condition of Load	Remarks
80	Rations	1250	34	70x96		≠100			1050		75	80	15			Malfunction induced by securing extr chute bag. Intentional to test emergency procedure for dual loads rigged for dual extr.
				DUAL EXTRACTION LOADS												
81	Sim Ammo -boxes	1250	25	70x96					1170							

APPENDIX III - FINDINGS

Requirement	Source	Degree of Compliance
1. Components used in LOLEX shall consist of standard items where practicable.	USATECOM	Met requirement (Tests Nr 1, 4, and 9).
2. Extraction will be accomplished while the CV-2B aircraft is flying close to the ground and at reduced speed thereby eliminating the necessity for recovery (cargo) parachutes.	USATECOM	Met requirement (Tests Nr 1, 4, and 9).
3. Platforms for LOLEX shall be constructed in various sizes required for efficient delivery of supplies and equipment.	USAAESW Board	Met requirement for platforms 70" wide and 8' to 14' in length. (Tests Nr 4 and 9).
4. LOLEX shall be capable of effecting air drop of supplies and equipment in combat serviceable condition from standard U. S. Army CV-2B aircraft, under the following conditions: a. While the aircraft is flying at the minimum feasible altitude. b. Without requirements for recovery parachutes.	USATECOM	Met requirement (Tests Nr 4 and 9).
5. LOLEX shall facilitate simple and rapid rigging and derigging of loads by troops without special training and with minimum use of special materiels handling equipment.	USAAESW Board	Met requirement (Test Nr 4).

Requirement	Source	Degree of Compliance
6. LOLEX shall provide for suitable load attitude during descent and landing.	USAAESW Board	Met requirement (Test Nr 4).
7. LOLEX shall ensure rapid recovery and immediate access on the ground to the supplies and equipment without hindrance from any nonstandard associated components.	USAAESW Board	Met requirement (Test Nr 4).
8. LOLEX shall not limit flexibility in positioning loads with respect to aircraft CG limitations.	USAAESW Board	Met requirement (Test Nr 4).
9. LOLEX shall require no major modification of standard vehicles or equipment to be delivered.	USAAESW Board	Met requirement (Test Nr 4).
10. LOLEX shall require no major modification of air delivery items or aircraft.	USAAESW Board	Met requirement (Test Nr 4).
11. LOLEX shall be compatible with the CV-2B capability for air drop.	USAAESW Board	Met requirement (Test Nr 4).
12. LOLEX shall be such that no components need be retrieved into the aircraft after air drop.	USAAESW Board	Met requirement (Test Nr 4).
13. Landed LOLEX components shall either possess characteristics which will render them useful in combat or shall be easily destroyed at the landing site to prevent detection.	USAAESW Board	Met requirement (Test Nr 4).

Requirement	Source	Degree of Compliance
14. LOLEX shall perform its mission within the limits of precision required for delivery of loads within 100 meters of the selected impact point.	USAAESW Board	Met requirement (Tests Nr 5 and 6).
15. The system shall perform its mission with maximum reliability under the following operating conditions:	USAAESW Board	
a. In ground winds from 0 - 30 knots.		Met requirement except that load survivability was not tested in ground winds in excess of 16 knots.
b. Delivery to be accomplished on varied terrain without dependence on large drop zones, extensive ground preparation, or extensive prepositioned ground equipment.	USAAESW Board	Met requirement (Tests Nr 5 and 6).
16. LOLEX shall permit the delivery of single loads from 1,000 to 4,000 pounds.	USATECOM	Met requirement (Test Nr 7).
17. The system shall permit the delivery of all loads of a size within the permissible load envelope for standard air drop from CV-2B aircraft.	USAAESW Board	Met requirement (Test Nr 7).
18. LOLEX shall not reduce the all-weather capability of CV-2B aircraft.	USAAESW Board	Met requirement (Test Nr 7).
19. LOLEX shall facilitate the immediate consecutive delivery of personnel without obstruction from system components.	USAAESW Board	Met requirement (Test Nr 7).

Requirement	Source	Degree of Compliance
20. LOLEX shall be such that the aircraft, associated equipment, and using personnel are exposed to minimum hazard.	USAAESW Board	Met requirement (Test Nr 8).
21. The design of LOLEX shall be such that visual inspection for operational readiness is possible at any time prior to use.	USAAESW Board	Met requirement (Test Nr 8).

APPENDIX IV - DEFICIENCIES AND SHORTCOMINGS

1. DEFICIENCIES

DEFICIENCY	SUGGESTED CORRECTIVE ACTION	REMARKS
The pendulum release system, currently in CV-2B aircraft, does not provide for positive ejection of the extraction parachute beyond the aircraft ramp.	Modify the parachute pendulum release system, as suggested in Test Nr 4 and Appendix X, after engineering determination of strength requirements for the hook (paragraph 2.4.4, Test Nr 4).	Test Nr 4, Appendix VI.2, and Appendix X.

2. SHORTCOMINGS

SHORTCOMING	SUGGESTED CORRECTIVE ACTION	REMARKS
The standard 22-foot extraction parachute alone does not provide for satisfactory operation when used in conjunction with LOLEX.	Provide a single pilot parachute bag for both the Pilot Parachute, Cargo Type, 5' 8" Diameter, FSN 1670-216-7297, and the Pilot Parachute, Personnel Type, 2' 2" Diameter, FSN 1670-251-6604, which can be used to deploy the 22-foot extraction parachute.	Test Nr 4 and Appendix VI.3.
The cockpit pendulum release switch, as presently installed in CV-2B aircraft, could not be safely actuated by the pilot and was awkward and difficult for the co-pilot to reach.	Relocate the cockpit pendulum release switch.	Test Nr 2 and Appendix IX.

3. CORRECTED DEFICIENCIES/SHORTCOMINGS

DEFICIENCY/SHORTCOMING	CORRECTIVE ACTION	REMARKS
None		

APPENDIX V - COORDINATION

Coordination of this report between participating agencies was accomplished at a conference at Fort Bragg, North Carolina, 20 - 21 August 1964.

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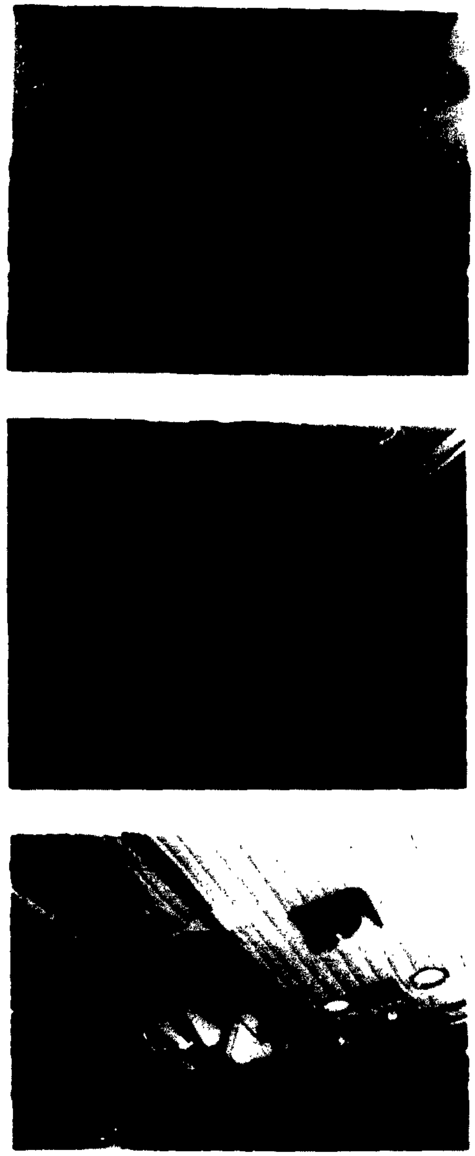
AND SPECIAL WARFARE BOARD
FORT BRAGG, NORTH CAROLINA
USATECOM NR 4-4-7475-01
PROJECT AB 5563
NEGATIVE 33
APPENDIX VI.1

"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

FINAL RESTRAINT OF LOAD

One-half inch (1,000-lb) tubular nylon webbing forward of the load. Final restraint is broken by the extraction force pull.



"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

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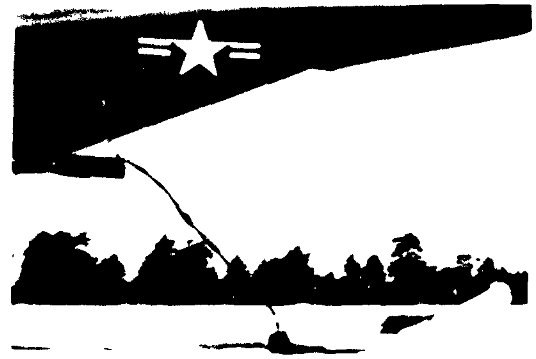
NEGATIVE 69,21,64
APPENDIX VI.2

MODIFIED PENDULUM SYSTEM

UPPER: Aft view of cargo compartment. Circle indicates location of ejector rack.

CENTER: New pendulum line hook and pulley.

LOWER: Ejector rack reversed.



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NEGATIVE ____________
APPENDIX VI,3

PILOT PARACHUTE BREAK-AWAY SYSTEM

UPPER: Deployment of pilot parachutes.

CENTER: Pilot parachutes deploy extraction parachute.

LOWER: After deployment of the extraction parachute, the pilot parachutes break away.

"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

PILOT PARACHUTE BAG

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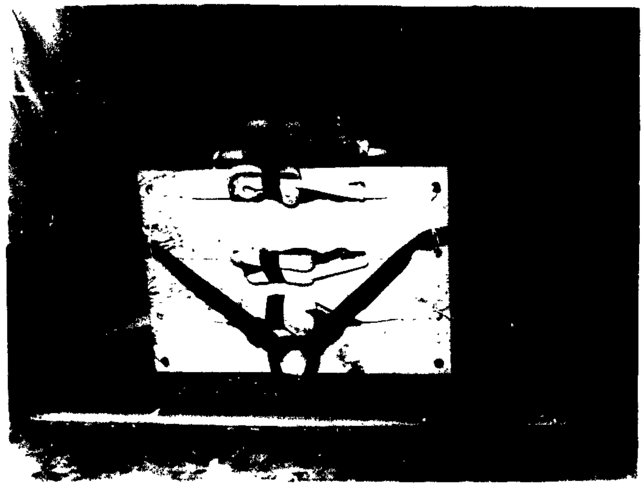
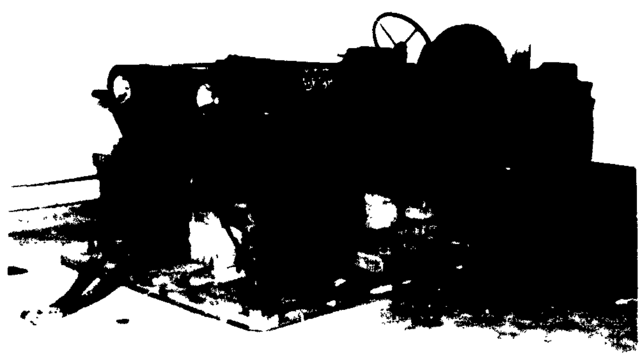
PROJECT AB 5563
NEGATIVE 72,71,29
APPENDIX VI.4

UPPER: Construction of pilot parachute bag.

CENTER: Pilot parachutes packed in pilot parachute bag and attached to extraction parachute bag.

LOWER: Extraction parachute, with pilot parachutes attached, installed in aircraft.





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"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

PROJECT AB 5563

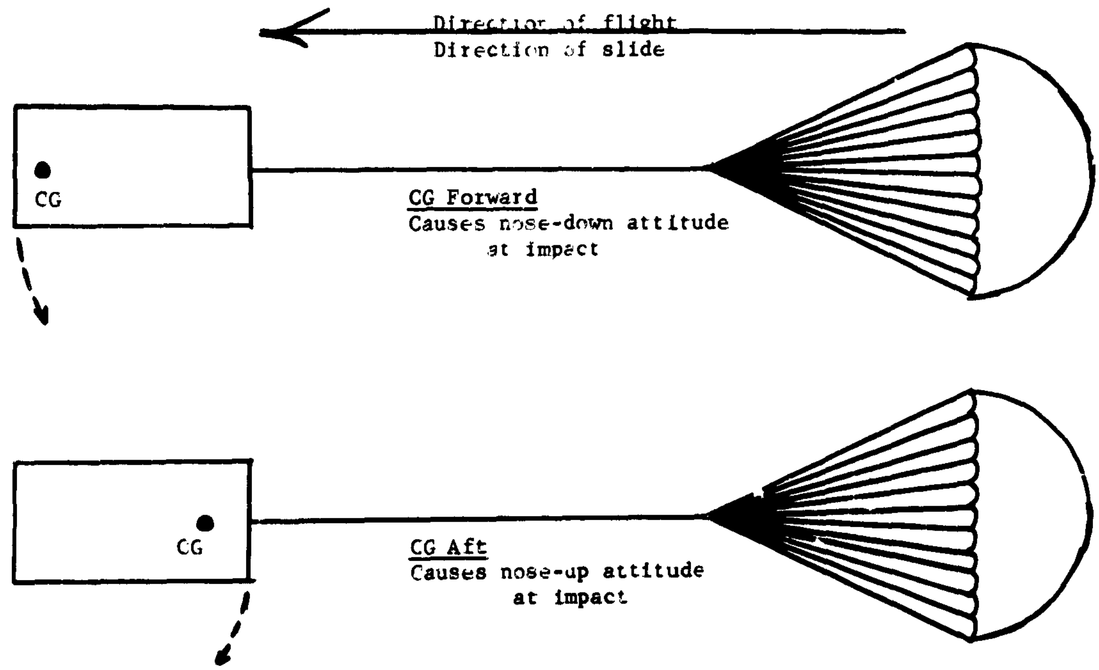
NEGATIVE 57,60

APPENDIX VI.5

UPPER: Typical mass load.

LOWER: Break-away system for vehicles.

EFFECT OF CG LOCATION



Dotted arrows show inclination as load drops.

NOTE: Side View - Lateral CG Centered

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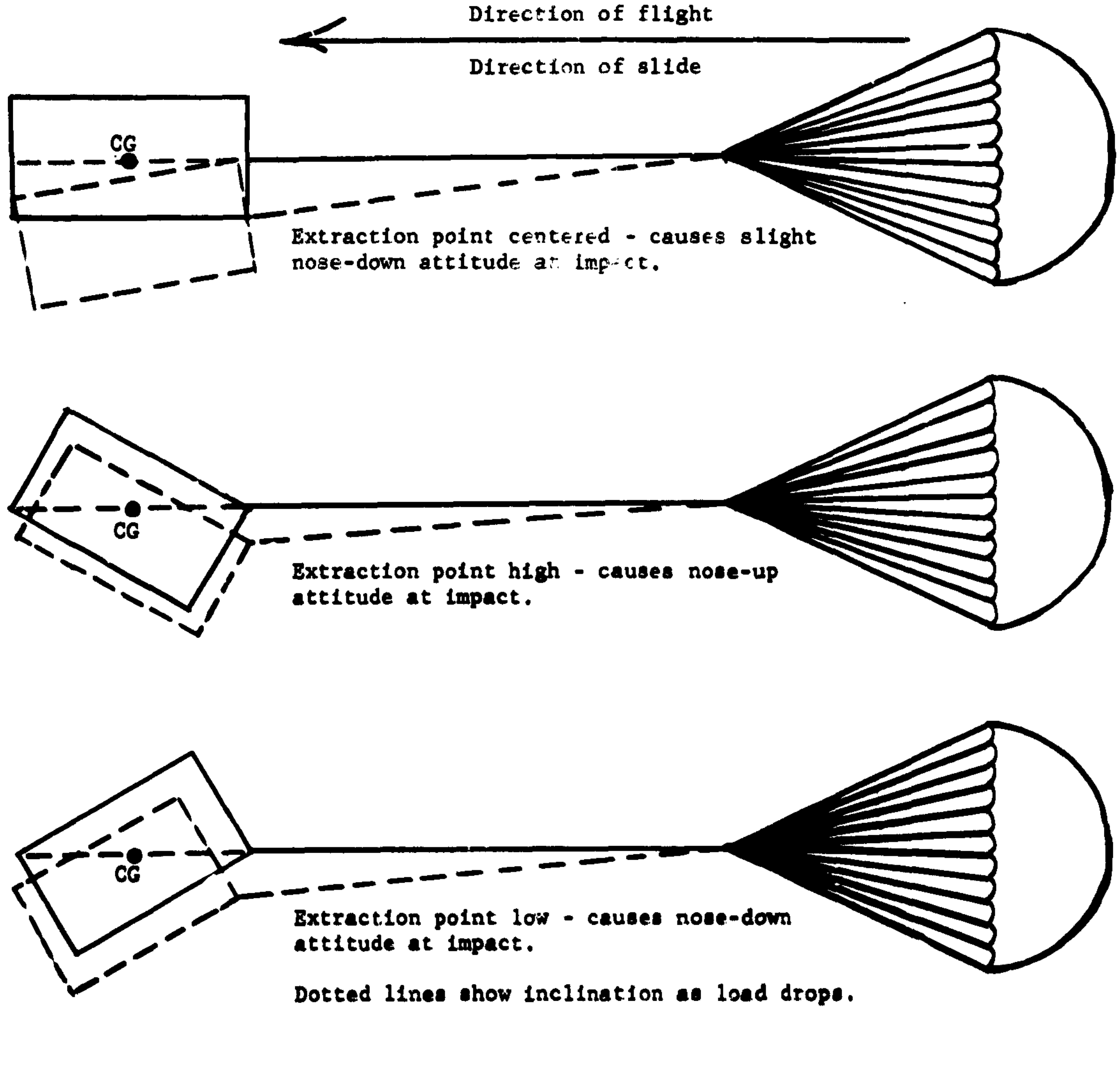
PROJECT AB 5563
NEGATIVE
APPENDIX VI.7

Lateral roll of the load (when using 15-foot extraction parachute).

EFFECT OF EXTRACTION PULL AROUND CG



NOTE: Side View - Lateral CG Centered

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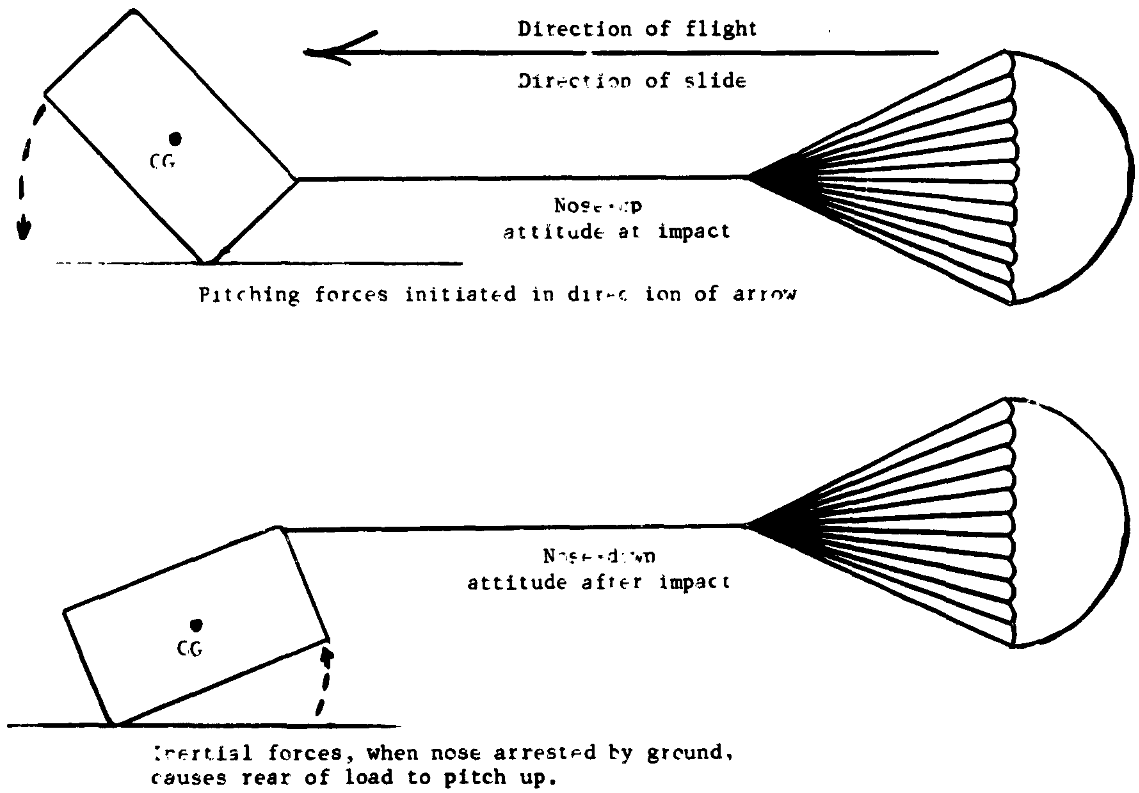
APPENDIX VI.8

EFFECT OF EXTREMELY HIGH NOSE-UP ATTITUDE



NOTE: Side View - Lateral CG Centered

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APPENDIX VI.9

"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

DROP ZONES

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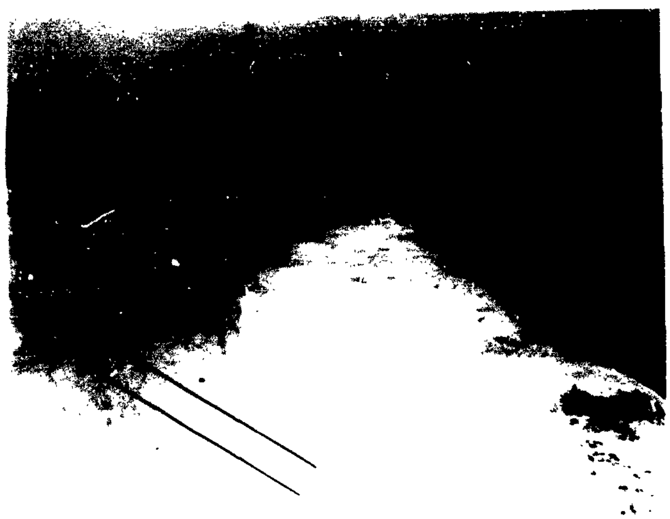
NEGATIVE 42,54
APPENDIX VI.10

UPPER: Extremely rough, uneven ground; scrub oak 3 - 6 feet tall.

LOWER: Extremely rough, uneven ground.
A - Scrub oak DZ
B - Tall grass DZ



"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

DROP ZONES

UPPER: A - Landing strip, hard clay and sand - undulating.

B - "T" in sand, impact area hard clay and sand. 500-foot impact area.

LOWER: Loose sand to a depth of 8 - 10 inches, undulating.

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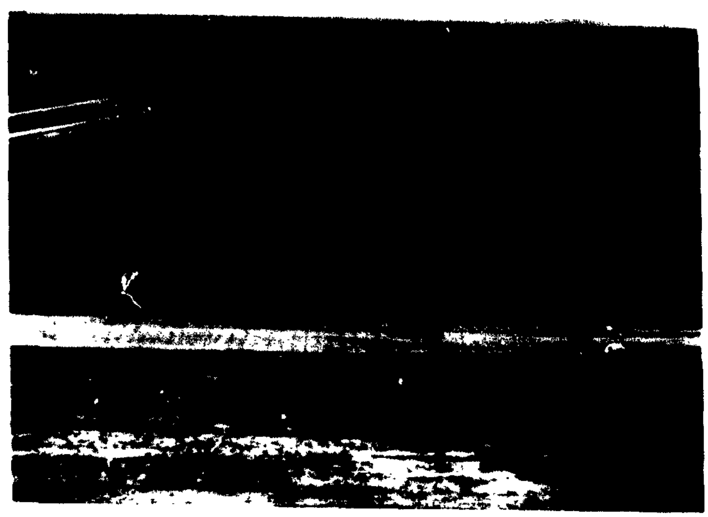
NEGATIVE 44,46
APPENDIX VI,11



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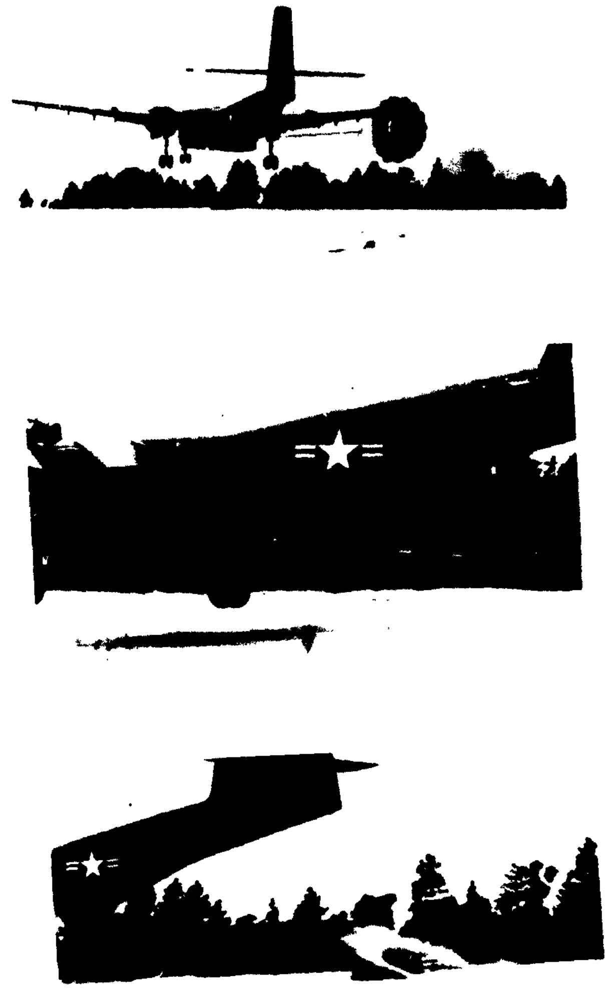
USATECOM NR 4-4-7475-01
PROJECT AB 5563
NEGATIVE 41,53
APPENDIX VI,12

"INTEGRATED ENGINEERING/SERVICE TEST OF LOW LEVEL EXTRACTION TECHNIQUES (LOLEX) FROM CV-2B AIRCRAFT"

DROP ZONES

UPPER: Hard clay and sand. 50-foot barrier on each end of 1,583-foot long runway.

LOWER: Dry grass, soft earth, level. (Circle - group of bushes used for Load Nr 30).



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PROJECT AB 5563
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APPENDIX VI.13

LOLEX SEQUENCE

UPPER: Extraction of the load is accomplished by parachute.

CENTER: Load as it leaves the ramp.

LOWER: Load at moment of impact.

APPENDIX VII - REFERENCES

1. Letter, AMSTE-BG, USATECOM, 29 November 1963, subject: "Directive for Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft, USATECOM Project Nr 4-4-7475."

2. Letter, AMSTE-BG, USATECOM, 20 January 1964, subject: "Plan of Test, USATECOM Project Nr 4-4-7475, Integrated Engineering/ Service Test of Low Level Extraction System (LOLEX) from CV-2B Aircraft."

3. Memorandum for Record, STEYT-TAT, Yuma Proving Ground, Yuma, Arizona, 25 February 1964, subject: "LOLEX/Caribou Test Organizational Meeting Held at Air Testing Branch, Test and Evaluation Division, Yuma Proving Ground, Arizona, 20 February 1964."

4. Memorandum STEYT-TAT, Yuma Proving Ground, Yuma, Arizona, 6 March 1964, subject: "LOLEX."

5. Message, STEAV-E 7-4-15, USAATA, 7 April 1964, subject: "Safety of Flight Release (LOLEX)."

6. Message, STEAV-E 10-4-19, USAATA, 10 April 1964, subject: "Recommendation for Safety of Flight Release of LOLEX Aerial Delivery System, CV-2B Caribou Aircraft."

7. Message, TT6349, AMSTE-BG, USATECOM, 15 April 1964, subject: "Safety Release for LOLEX."

8. Message, TT6587, AMSTE-BG, USATECOM, 20 April 1964, subject: "Low Level Extraction Techniques from CV-2B Airplane (LOLEX)."

9. TM 55-1510-206-10, Operator's Manual AC-1 Aircraft, June 1962, with changes.

10. TM 10-500, Aerial Delivery of Supplies and Equipment General, November 1963.

11. TM 10-500-5, Air Drop of Supplies and Equipment: AC-1 and AC-1A (Caribou) Army Aircraft, Preparation, Loading, and Load Release Procedures, January 1962.

APPENDIX VIII - TEST PERSONNEL

Key personnel involved in the LOLEX tests w/CV-2B aircraft.

Name	Rank	Organization
Edward J. Nyenhuis	Civilian	USAAESW Board
Charles C. Neal	Captain	USAAESW Board
John T. Blaha	Civilian	USAATA
Michael N. Antoniou	Captain	USAATA
David Griffin	Civilian	Yuma Proving Ground
William Gilkes	Captain	Yuma Proving Ground
John Young	Major	USAAVNTBD
R. L. Shackleford	SFC E-7	USAQMS

APPENDIX IX -

ENGINEERING TEST REPORT,

U. S. ARMY AVIATION TEST AGENCY

HEADQUARTERS
U. S. ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA

STEAV-O 13 July 1964

SUBJECT: Final Test Report of the Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft, USATECOM Project No. 4-4-7475

TO: President
U. S. Army Airborne, Electronics & Special Warfare Board
ATTN: STEBF-AB
Ft. Bragg, North Carolina

SECTION 1 - GENERAL

1. References:

a. Letter, AMSTE-BG, U. S. Army Test & Evaluation Command, 29 November 1963, subject: "Directive for Integrated Engineering/ Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft."

b. Electrical Message, STEBF-AB 6-17, U. S. Army Airborne, Electronics & Special Warfare Board, 10 June 1964, subject: "LOLEX Report."

c. Electrical Message STEAV-C 7-4-15, U. S. Army Aviation Test Activity, 7 April 1964, subject: "Interim LOLEX Report."

d. Military Specification MIL-F-8785 (ASG), "Flying Qualities for Piloted Airplanes," 17 April 1959.

e. "Stability and Control Techniques," U. S. Naval Test Pilot School, February 1963.

f. TM55-1510-206-10, "Operator's Manual, AC-1 Aircraft," June 1962.

2. Background:

a. During joint exercise "Swift Strike III" in 1963, the 10th Air Transport Brigade, Ft. Benning, Georgia, demonstrated a low-altitude

aerial delivery from the CV-2B airplane. As a result of this demonstration, the U. S. Army Materiel Command, in November 1963, directed the U. S. Army Test & Evaluation Command to conduct an expedited test of the low-level extraction system (LOLEX) and the techniques involved in its use. In response to this requirement, the U. S. Army Test & Evaluation Command, on 29 November 1963, issued a directive (Reference a.) for an Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft. The U. S. Army Airborne, Electronics & Special Warfare Board (USAAESWBD) was designated Executive Test Agency and the U. S. Army Aviation Test Activity (USAATA) was designated a Supporting Test Agency, with "primary interest in engineering portion of test as pertains to the aircraft structure and stability and control." On 20 February 1964, representatives from the USAAESWBD, USAATA and the Air Testing Branch, Yuma Proving Ground, held a coordinating conference at Yuma Proving Ground, Arizona, to define the functions of the participating test agencies and the scope of the Integrated Engineering/Service tests. As a result of this conference, it was determined that the USAATA tests should include an evaluation of certain critical airplane performance parameters to validate the flight safety of the LOLEX system.

b. Engineering flight testing of the LOLEX system was completed by USAATA on 3 April 1964. Following completion of testing, an interim report, containing essential test results, was disseminated to all participating test agencies. Following complete analysis of test results and in accordance with instructions received from the President, USAAESWBD (Reference b), this final report was prepared.

3. Objectives

The objective of this evaluation was to investigate the flying qualities and performance of the CV-2B airplane during LOLEX operations, to develop a suitable LOLEX airplane configuration and flight envelope and to define safety of flight considerations pertinent to LOLEX operations.

4. Description of Materiel

The low-level extraction (LOLEX) system is comprised of a standard CV-2B airplane equipped with cargo roller conveyors, an air drop delivery system, as detailed in Reference f. and palletized cargo loads. All components of the system are standard service items and no special (nonstandard) equipment is required to complete LOLEX drops.

The loads, mounted on pallets, are positioned in the airplane on the roller conveyors and restrained with standard restraint equipment. A standard cargo extraction parachute is attached to the load and suspended from the air drop "pendulum" at the rear of the airplane. The load restraints are removed in flight. Next, the pilot actuates the pendulum release switch, thereby causing the release of the extraction parachute package. Deployment of the parachute is obtained as the package free falls into the slipstream, followed by cargo load extraction from the airplane through the rear cargo doors.

5. Scope and Method of Tests

a. In accordance with the requirements of paragraph 1, Reference a, and paragraph 3 above, the scope of the evaluation was designed to achieve the following objectives:

(1) The definition of the optimum airplane configuration for LOLEX operations from the standpoint of performance, stability and control.

(2) The definition of an airspeed gross weight envelope that would yield maximum flight safety consistent with operational requirements.

(3) The definition of safety-of-flight considerations as a result of failure of an engine or the "hang-up" of a deployed extraction parachute during the LOLEX drop sequence and the development of procedures by which emergency performance of the airplane could best be utilized.

(4) The determination of the combined effects of the characteristics of the airplane and the characteristics of the air-drop system on the LOLEX operation.

b. All LOLEX testing was accomplished at, or in the vicinity of, Edwards Air Force Base, California. Instrumentation of the test airplane was completed on 9 March 1964, the first test flight was flown on 10 March 1964 and the sixteenth and final test flight was completed on 3 April 1964. A total of 22.5 test hours was flown.

c. Although the weight of the air drop loads to be tested was specified in Reference a, airplane test gross weights were not defined. Airplane test gross weight range was determined by analyzing the various combinations of payload and fuel that would yield a typical service loading. Analysis of the empty weight of the airplane, crew weight, oil weight and the specific range characteristics of the CV-2B showed that, with a 1500-pound air drop load, a fuel quantity sufficient for a radius of action of 100 nautical miles with thirty minutes fuel reserve would result in a gross weight of approximately 24,000 pounds. This gross weight was used as a minimum test weight. Airplane gross weights tested, therefore, ranged from 24,000 pounds to 28,500 pounds, the maximum gross weight authorized for the CV-2B airplane.

d. Performance, stability and control characteristics of the CV-2B were tested through a speed range from 60 knots IAS to 100 knots IAS. This speed range was in accordance with the requirements of Reference a. Testing at speeds higher than 100 knots IAS was not practical due to flap structual limitations and landing gear structural limitations. Testing at speeds lower than 60 knots IAS was not accomplished because of the known deterioration in airplane performance and flying qualities at these lower speeds.

e. Center of Gravity (C.G.) of the airplane was varied during the evaluation to determine the suitability of the C.G. range of the CV-2B as outlined in Reference f. for LOLEX operations.

f. Concept of Tests - Tests were conducted on a buildup basis. Prior to actual LOLEX drop testing, it was necessary to define an optimum LOLEX airplane configuration. Using this configuration, a flight envelope was then developed within which satisfactory airplane performance and flying qualities could be obtained at all required test conditions. Since the minimum airspeed extremity of this flight envelope was determined by single-engine capability, this phase

of the evaluation was also utilized to conduct the initial investigation of the single-engine characteristics of the CV-2B in the LOLEX configuration. An evaluation of the characteristics of the airplane with a hung extraction chute was conducted next. Upon completion of this phase of testing, sufficient safety of flight data (single-engine and hung-chute considerations) had been accumulated to allow the initiation of LOLEX drops at altitude. These drops were utilized to obtain an initial verification of the suitability of the LOLEX configurations and flight envelope that had been developed. Final test phase conducted prior to actual LOLEX height drops was the verification of the suitability of the single engine characteristics of the CV-2B at LOLEX drop heights. This test phase was also used to verify the suitability of single-engine procedures that had been developed as a result of the altitude tests. Final tests of this program consisted of drops at LOLEX heights. These tests were utilized to verify the results of all previous testing under actual LOLEX flight conditions.

g. In accordance with the Concept of Tests given in paragraph f., the scope of this evaluation was divided into six test phases as follows:

(1) Airplane Configuration Optimization

(2) Determination of Minimum LOLEX Approach Speeds Based on Single Engine Performance Capability (High Altitude Tests)

(3) Determination of Airplane Characteristics with a Hung Extraction Parachute

(4) LOLEX Drops (High Altitude Tests)

(5) Verification of Proposed Minimum LOLEX Approach Speeds Based on Single Engine Capability (LOLEX Height Tests)

(6) Drops at LOLEX Heights

For the detailed scope and method of the evaluation for each test phase, see Section II, Details of Tests.

STEAV-O [illegible] July 1964

SUBJECT: Final Test Report of the [illegible] Engineering/Service Test of Low Level Extraction [illegible] (LOLEX) from CV 2B Aircraft, USATECOM Project No. [illegible]

6. Findings:

Within the scope of these [illegible] it was determined that:

a. Performance, stability and control characteristics of the CV-2B airplane were suitable for LOLEX operations.

b. The following airplane configurations yielded satisfactory approach attitudes, performance and flying qualities:

(1) For Approach Speeds [illegible] Knots IAS

(a) Landing gear [illegible]
(b) Flap setting [illegible]
(c) Power [illegible] flight
(d) Propeller control [illegible] rpm setting
(e) Ramp door [illegible]
(f) Cargo door [illegible]
(g) Autofeathering [illegible]

(2) For Approach Speeds [illegible] Knots IAS

(a) Landing gear down
(b) Flap setting [illegible]
(c) Power as required [illegible] flight
(d) Propeller control [illegible] rpm setting
(e) Ramp door [illegible]
(f) Cargo door open
(g) Autofeathering [illegible]

c. The following flight envelope yielded satisfactory airplane performance, flying qualities and [illegible] pitch attitudes when the airplane was operated in the configurations listed in 6 b

(1) Minimum LOLEX Approach Speeds

(a) 24,000 pounds [illegible] knots IAS
(b) 26,000 pounds [illegible] knots IAS
(c) 28,500 pounds 90 knots IAS

(2) Maximum LOLEX Approach Speeds

(a) At 15 degree flap settings 92 knots IAS
(b) At [illegible] degree flap settings [illegible]00 knots IAS

(3) Airplane [illegible]

All gross [illegible] pounds and the maximum authorized gross weight [illegible]

(4) Airplane [illegible]

As specified [illegible]

(5) Sling [illegible]

A[illegible] pounds

d The CV-2B [illegible] performance for prolonged flight with [illegible] extraction parachute deployed This [illegible] a device which could be used to [illegible] from the airplane

e Adequ[illegible] control could be consistently obtained [illegible] the LOLEX drop sequence provided the [illegible] and flight envelope given in 6b and [illegible] following procedure was utilized [illegible]

(1) A m[illegible] speed not lower than the minimum [illegible] the appropriate weight as listed [illegible]

(2) Jett[illegible] system (if necessary)

(3) Appl[illegible] power settings

(4) Feather[illegible]

(5) Retraction [illegible]

(6) Retraction [illegible]

f Balanced [illegible] flight should be maintained during the [illegible] load contact with the interior side [illegible] extraction

g. A tactical LOLEX ... carried out over 50 foot barriers, as executed in ... require a minimum field length of approximately 1460 feet at ... weight of 28,000 pounds using an approach airspeed of ... knots ... altitude of 2300 feet.

h. The pendulum release ... presently installed in the CV-2B, could not be safely actuated ... and was ... and difficult for the copilot to ...

i. The time required ... extraction following actuation of the extraction system ... reduced drop accuracy.

j. All performance ... report are for test day conditions only ... effect of varying atmospheric conditions on ... sufficient additional engineering tests should be ... define CV-2B LOLEX performance parameters ...

7. Conclusions

Within the scope of ... concluded that:

a. Using the recommended ... and flight envelope, CV-2B LOLEX operations ... use.

b. Using the recommended ... limitations and flight envelope, twin engine performance ... of the CV-2B airplane are suitable for LOLEX operation.

c. A device that can be used ... a hung extraction parachute from the airplane should be ... the LOLEX system.

d. Using single engine procedures developed in these tests, adequate single-engine performance and control can be obtained following an engine failure during the LOLEX sequence.

e. Balanced (bail ...) ... maintained during the LOLEX extraction sequence.

... desirable for LOLEX operation.

g. A reduction in the time required for load extraction would probably improve drop accuracy.

h. Additional engineering testing should be accomplished to define CV-2B LOLEX performance for all operating conditions.

8. Recommendations

It is recommended that:

a. LOLEX configurations and the LOLEX flight envelope developed in this evaluation be adopted for LOLEX service operations.

b. Development of a device to separate a hung chute from the drop airplane be initiated.

c. Single-engine procedures developed in this evaluation be adopted for LOLEX service operations.

d. Balanced (ball-centered) flight be maintained during the LOLEX extraction sequence.

e. The cockpit pendulum release switch be relocated.

f. Further engineering testing of the LOLEX system be conducted to define CV-2B LOLEX performance for all operational conditions.

g. Operational units engaged in LOLEX operations be briefed on the results of these tests.

SECTION II DETAILS OF TESTS

1. Airplane Configuration Optimization for LOLEX Operations

Testing to obtain the optimum airplane LOLEX configuration was concerned primarily with determining flap deflection angles that would yield favorable airplane (and therefore cargo compartment) attitudes throughout the desired airplane gross-weight range and favorable single-engine performance and flying qualities at the lowest possible LOLEX approach speeds.

Level flight runs were made at preselected, stabilized airspeeds ranging from 60 knots indicated airspeed (IAS) to 100 knots IAS, using flap deflections of 0, 7, 15 and 25 degrees. Pressure altitude was 5000 feet and airplane gross weight ranged from 24,000 pounds to 26,500 pounds. The cargo door was fully open and the ramp door was open to the level position. With an oscillograph and an angle-of-attack string, flight control positions, pitch, roll and yaw attitudes and airplane angle of attack were recorded. Engine power output was noted and results were correlated with qualitative pilot observations to determine those combinations of airspeed and flap deflection that yielded the most favorable flying qualities and airplane pitch attitudes.

Airplane angle of attack (and therefore pitch attitude) is directly proportional to gross weight and inversely proportional to the square of the calibrated airspeed. This aerodynamic relationship formed the basis for the flap deflection investigation. At a fixed calibrated airspeed and gross weight, increasing flap deflections requires the pilot to use increasingly larger nose-down airplane pitch attitudes. These larger nose down pitch attitudes are required because lowering the flaps produces larger angles of attack and thus increased lift and drag, which the pilot offsets by decreasing the pitch attitude of the airplane to maintain the desired fixed speed and altitude. The pitch attitude of the airplane, therefore, is determined by the flap deflection selected.

These relationships were analyzed as they pertain to the CV-2B airplane and following testing, the results were correlated with pilot observations. It was determined that pitch attitudes in excess of approximately 3 degrees nose up and 3 degrees nose-down were considered unsatisfactory by the evaluating pilot. At pitch

attitudes in excess of 3 degrees nose-up, visibility was marginal; and at pitch attitudes in excess of 3 degrees, nose-down, the evaluating pilot observed that he felt uncomfortable, as though he were sliding forward out of the seat. Additionally, it was determined that, at large nose-down pitch angles, if the airplane were to contact the ground during a LOLEX drop sequence, it would do so nose-wheel first. This was unacceptable owing to nose-wheel structural considerations.

In addition, it was required that the selected flap deflection yield satisfactory single-engine performance and control characteristics. Maximum single-engine climb performance is obtained with zero flap deflections. Controllability also generally improves as flap deflection is decreased. These characteristics, however, were not compatible with the requirement for near level pitch attitudes at relatively slow speeds, as described above. These tests were, therefore, aimed at the selection of a flap deflection for LOLEX operations that would satisfy both requirements.

Stabilized level flight runs were initially executed at a flap deflection of zero degrees. At this flap deflection, airplane performance and flying qualities were satisfactory throughout the speed range tested. At all gross weights, however, an excessively nose-high pitch attitude was obtained at indicated airspeeds below 90 knots. In addition, analysis of contractor data showed that, at indicated speeds below 90 knots, there was a significant loss of single-engine performance at this flap setting. These characteristics eliminated this flap configuration from further consideration.

Level flight runs were then accomplished using a 15-degree flap angle. At this flap-deflection angle, pitch attitude was within desired limits at all gross weights within an airspeed range from 100 knots IAS down to 70 knots IAS. Flying qualities were also suitable throughout this speed range, but power required to stabilize at speeds above 92 knots IAS was excessive, particularly at heavy gross weights. This flap setting yielded a favorable thrust/drag ratio for single-engine performance at light gross weights but produced an unfavorable ratio at heavy gross weights.

Level flight runs were next executed at a flap deflection of 7 degrees. At this flap angle, airplane pitch attitude was

satisfactory through an airspeed range from 100 knots IAS down to 84 knots IAS. Flying qualities and power required were also suitable throughout this speed range, but pitch attitude became excessively nose-high at speeds below 84 knots IAS. Single-engine performance thrust/drag ratios were satisfactory at all gross weights within the airspeed range noted.

Final runs were executed at a flap deflection of 25 degrees. At this flap setting, pitch attitude was excessively nose-down at indicated airspeeds in excess of 84 knots IAS at a moderate gross weight of 26,000 pounds. An excessive level of power was required to obtain stabilized speeds in excess of 80 knots IAS. At speeds between 84 knots IAS and 60 knots IAS, pitch attitude and flying qualities were acceptable, but speed stabilization was difficult because of the thrust/drag relationships obtained at this flap setting. Additionally, owing to the high levels of induced drag obtained, single-engine performance would have been unacceptable at all gross weights tested. This flap setting would be useful, however, in making slow-speed LOLEX approaches where the compromise of single engine safety was not a limiting consideration.

As a result of the testing described above, it was determined that flap settings of 15 degrees at speeds up to 85 knots IAS and 7 degrees at speeds above 85 knots IAS would produce satisfactory pitch attitudes, single engine performance, flying qualities and power-required characteristics at all gross weights within a range from 24,000 pounds to 28 500 pounds.

Other items that were considered in completing airplane configuration testing were

a. Landing Gear Position - Although extension of the landing gear produced a significant increase in parasite drag, it was determined qualitatively that the landing gear should be extended for LOLEX operations. The validity of this configuration was confirmed following actual LOLEX drops where several ground contacts were inadvertently experienced owing to pilot misjudgment of height. Additionally, it was found that atmospheric turbulence, uneven terrain and the close proximity of the airplane to the ground placed psychological stress on the pilot when LOLEX runs were executed with the landing gear retracted.

b. Power - Stabilized power settings for level flight should be utilized for straight-in, constant-height approaches to avoid unnecessary retrimming procedures.

c. Propeller Controls - Propeller controls should be placed at the takeoff rpm setting to reduce complexity of cockpit procedures following an engine failure during the drop sequence.

d. Cargo Door - Cargo door should be fully open.

e. Ramp Door - Ramp door should be opened to the level position. It was determined that depressing the ramp door to angles below level increased turbulence and power required for level flight and did not improve the flying qualities of the airplane.

f. Autofeathering - Autofeathering should be disarmed for LOLEX operations to preclude inadvertent feathering of a partially failed engine and/or inadvertent feathering caused by an asymmetrical application of power following the drop sequence.

In summary, within the scope of these tests, the following airplane configurations were found to be satisfactory for LOLEX operations at all gross weights tested:

a. For LOLEX Approach Speeds Up to 85 Knots IAS:

(1) Flap setting - 15 degrees
(2) Landing gear - down
(3) Power - as required for level flight
(4) Propeller control - takeoff rpm setting
(5) Cargo door - fully open
(6) Ramp door - open to the level position
(7) Autofeathering circuit - disarmed

b. For LOLEX Approach Speeds Above 85 Knots IAS:

Flap setting of 7 degrees. All other items as listed above in a.

2. Determination of Minimum LOLEX Approach Speeds Based on Single-Engine Performance Capability (High Altitude Tests).

Definition - For the purposes of identification within this report, to avoid confusion, the speeds defined as minimum LOLEX

approach speeds are also the minimum speeds at which satisfactory single-engine performance can be obtained. Single-engine performance, stability and control characteristics of the CV-2B, coupled with pilot capability and an evaluation of psychological effects on the pilot following loss of an engine, formed the basis for the minimum LOLEX approach speeds presented in this report.

These tests were conducted based on the following assumptions:

a. That the airplane would not be allowed to contact the ground following an engine failure during the LOLEX drop sequence.

b. That, following failure of an engine, a safe recovery and climb over a 50-foot obstacle could be accomplished with no unusual degree of pilot skill.

Testing was accomplished at or below a pressure altitude of 3000 feet to obtain rated takeoff power on the operating engine following the engine failure. The airplane was placed in the LOLEX configuration using the optimized flap settings developed in previous testing. Indicated airspeed was then stabilized at preselected values in a range from 100 knots IAS to 60 knots IAS, with power set for level flight. Power on the critical (left) engine was then abruptly chopped to produce a propeller-windmilling condition and airplane reaction and pilot control inputs were recorded with an oscillograph and sensitive cockpit instrumentation. Various cockpit procedures were employed to determine the optimum single-engine procedure for the LOLEX configuration. Testing was continued at decreasing airspeed values until an airspeed was reached at which immediate single-engine recovery was not possible without resort to unusual pilot techniques. The quantitative data obtained at each airspeed tested was then analyzed and correlated with the test pilot's qualitative comments to determine the minimum safe LOLEX approach speeds.

The following parameters were evaluated:

a. Pilot Reaction Time.

b. Transient airplane dynamic pitching, rolling and yawing following engine failure.

c. The effects of "zooming" the airplane following engine failure.

d. Cockpit single-engine procedures.

e. Static control forces and displacements.

The following are the results of evaluating the parameters listed above:

a. Pilot Reaction Time

Based on past experience and on known pilot reactions to single-engine emergencies, it has been determined that it would be unrealistic to assume an instantaneous reasoned pilot reaction. It is, however, probable that reflexive pilot reaction would be obtained, based on training and an immediate observation of transient airplane response following the failure. Based on this probability and previous experience, it was assumed, therefore, that a period of five seconds would be required prior to initiation of any reasoned pilot reaction. All single-engine testing was conducted using this five-second delay in pilot reasoned response, and minimum LOLEX approach speeds were determined using this delay parameter.

b. Transient Airplane Dynamic Response

Transient dynamic response of the airplane was evaluated by suddenly chopping an engine with the controls maintained in a fixed position and quantitatively and qualitatively noting the response of the airplane. This response was considered to be of major importance since, at the drop heights used for LOLEX operations, an excessively large response could cause ground contact prior to pilot recovery action. In accordance with the requirements of Reference d, Section I, paragraph 1., it was determined that transient yawing and rolling should not be of such magnitude or rate that a heading change in excess of 20 degrees would be obtained prior to pilot corrective action. Additionally, it was determined that no excessive nose-down pitching should occur which could cause ground contact.

Transient dynamic response of the CV-2B was satisfactory at all weights and centers of gravity tested. Rates of roll, yaw and pitch were such that no difficulty was experienced in regaining control of the airplane following engine failure at speeds down to 60 knots IAS. It was determined, however, (1) that at speeds below the minimum single-engine control speeds listed in Reference f, Section I, paragraph 1, application of takeoff power on the operating engine caused a dynamic, lateral directional oscillation that was difficult to stop precisely because of a lack of lateral directional control power and (2) that steady-heading flight could not be maintained for the same reason. This would be unacceptable following an engine failure during a LOLEX drop sequence. It was determined, therefore, that speeds below the appropriate minimum single-engine control speeds listed in Reference f, Section I, paragraph 1., should not be utilized following engine failure during the LOLEX sequence.

Observation of indicated airspeed showed that, following an engine failure, an immediate bleed-off of airspeed occurred due to the windmilling propeller on the failed engine. Magnitude of this airspeed loss ranged from 8 to 10 knots, depending on the attitude of the airplane immediately following the failure. To preclude a loss in airspeed to a value below the minimum single-engine control speed, therefore, it was necessary to utilize an initial engine failure speed approximately 10 knots higher than the minimum control speed for the particular test gross weight. These minimum acceptable initial engine-failure speeds were determined to be 70, 75 and 85 knots IAS for gross weights of 24,000, 26,000 and 28,500 pounds, respectively, as a result of additional testing. Airplane dynamic response at these speeds was satisfactory, and no difficulty was experienced in maintaining the minimum single-engine control speed following engine failure.

c. <u>The Effects of Zooming the Airplane Following Engine Failure</u>

These tests were conducted to determine the effect of a modified "zoom" on the single-engine performance, stability and control characteristics of the CV-2B. Investigation of the LOLEX

maneuver revealed that time available for the pilot to initiate corrective action following engine failure was more critical than that available following engine failure during takeoff with the airplane climbing through a height comparable to a nominal LOLEX height. During takeoff, the operating engine would already be at takeoff power rather than at some reduced power level as in LOLEX runs. This is significant because the additional power would improve climb performance during the time immediately following the failure. In addition, with takeoff power already applied, one less physical step in the single-engine procedure would be required thereby further enhancing recovery. Finally, during takeoff, the airplane would be accelerating and climbing, thus aiding recovery procedures. Because of the variation in these parameters between the takeoff operation and the LOLEX operation, it was determined that currently employed takeoff single-engine procedures would not produce optimum results when applied to engine failures in the LOLEX configuration. This fact was verified during subsequent engine chops at LOLEX heights.

The normal pilot reaction, upon losing an engine at LOLEX heights, would be to apply aft control to prevent the airplane from striking the ground. It was reasoned that since this reaction was reflexive in nature, it could be utilized to place the airplane in a more favorable position for the initiation of reasoned single-engine procedures. By applying additional aft control, a modified "zoom" could be developed that would place the airplane well clear of the ground and thus allow sufficient time to employ single-engine procedures.

Testing of the "zoom" technique following engine failure indicated that satisfactory results would be obtained at LOLEX heights. Following sudden failure of the critical (left) engine, the evaluating pilot immediately applied aft longitudinal control to establish the "zoom". Height gained during the zoom varied from 50 feet to 100 feet. No difficulty was experienced in maintaining control of the airplane at "zoom" speeds down to the single-engine minimum control speeds listed in Reference f, Section I, paragraph 1. for the appropriate gross weight. Further investigation by the evaluating test pilot showed that the "zoom" technique produced consistent results with no unusual pilot skill when an engine was failed at indicated airspeeds down to 71, 77 and 85 knots for gross weights of 24,000, 26,000 and 28,500 pounds, respectively. To provide a margin of safety for inexperience, pilot unfamiliarity, unfavorable terrain and unusual stress as in combat, a five-knot

buffer was applied to these speeds. These results formed the basis for the minimum LOLEX approach speeds recommended and are presented graphically in Figure No. 1, Appendix.

d. Cockpit Single-Engine Procedures

Various cockpit single-engine procedures were tested to determine which procedure would produce optimum results. In accordance with previous reasoning, it was determined that the procedure should provide the pilot with the maximum time in which to determine which engine had failed, whether the failure was complete or partial, and following this, whether to feather or not to feather. To obtain maximum time for corrective action, it was concluded that jettisoning of the drop load with the extraction system should be considered, since a reduction in gross weight would significantly improve single-engine performance immediately following engine failure. Analysis of the LOLEX drop sequence showed that, assuming there were barriers or unfavorable terrain at both ends of the LOLEX approach course, the most critical time for an engine failure would be when the airplane was approaching the drop point and was already established at minimum height. An analysis of the dynamic response of the aircraft following sudden engine failure indicated that no unfavorable control characteristics would result if the load were jettisoned during the "zoom" sequence following the failure.

First Step

In view of the foregoing analysis, it was determined that, following an engine failure during the LOLEX run and initiation of the "zoom" maneuver, the first step should be to extract the load unless it was obvious that safe single-engine flight or landing could be accomplished without this step. Load jettisoning was employed during a subsequent engine chop at LOLEX height, and the results confirmed the feasibility of this step.

Second Step

Following the "zoom" (and jettisoning, if employed), it was determined that the next step should be the application of takeoff power settings on both engines without attempts to distinguish which engine had failed. Since, using the recommended LOLEX configuration, the propeller controls would already be at

takeoff settings, this step would involve only the application of both throttles to takeoff settings.

To determine whether the next step should be to feather the failed engine or to raise the landing gear, an analysis of contractor performance data was made to determine which item had the most adverse effect on climb performance. With takeoff power applied on one engine (assuming that the other engine had, in fact, failed), climb performance of the CV-2B was found to be extremely marginal with the landing gear extended and the propeller of the failed engine windmilling. This was caused by the parasite drag produced by the windmilling propeller and the extended landing gear. This analysis showed that the windmilling propeller had more adverse effects at speeds near the minimum control speeds. It was determined that feathering first had the added advantage of reducing lateral-directional control forces because of the asymmetric power condition. Retaining the landing gear in the down position additionally would have obvious advantages should the pilot elect to land following feathering of the failed engine.

Third Step

It was determined, based on the above analysis, that application of takeoff power should, therefore, be followed by feathering of the failed engine.

Assuming that feathering had been accomplished, analysis of contractor data showed that a small but positive rate of climb would be possible at all gross weights in the speed range between the minimum LOLEX approach speeds and the single-engine minimum control speeds.

Fourth Step

In view of the above, the next step, therefore, should be to raise the landing gear to improve climb performance and to allow acceleration to, and stabilization at, contractor-recommended safe single-engine speeds.

Following landing-gear retraction and airspeed stabilization at safe-single engine speed, the next step in the procedure would be to raise the flaps to zero deflection to further

improve rate of climb and to allow acceleration to clean configuration climb speed. It was determined that, depending on airspeed, attitude and gross weight at the initiation of flap retraction, raising the flaps to zero settings in one step could result in placing the airplane at an angle of attack where unfavorable thrust/drag ratios were obtained, thus causing a significant, transient loss in climb performance. Due to the close proximity of the airplane to the ground, this could be dangerous.

Fifth Step

It was determined that the flaps should be raised in steps while maintaining a continuous rate of climb and increase in airspeed until reaching the desired clean configuration single-engine climb speed.

The single-engine procedure found to produce optimum results for LOLEX operations was as follows

(1) Employment of the "zoom" technique to a speed not lower than the single-engine minimum-control speeds listed in the "Operator's Manual, AC-1 Aircraft" for the appropriate gross weight.

(2) Jettison of cargo by means of the extraction system (if necessary).

(3) Application of both throttles to takeoff power settings.

(4) Determination of the failed engine and feathering, as necessary.

(5) Retraction of the landing gear.

(6) Retraction [illegible] flaps in steps while maintaining a positive rate of climb and positive airspeed acceleration until reaching the desired clean configuration single-engine climb speed.

This procedure was subsequently tested during runs at LOLEX heights and found to produce consistently favorable results when the airplane was operated in the recommended LOLEX configuration and within the recommended LOLEX flight envelope.

e. Static Control Forces and Displacements

Static control forces and displacements were quantitatively and qualitatively evaluated throughout the single-engine test phase. At all speeds within the recommended LOLEX flight envelope, the CV-2B exhibited satisfactory static stability about all axes following engine failure and during "clean-up" of the airplane. All static forces required to maintain steady-heading, constant-attitude flight were well within pilot capability, and all required control displacements were easily obtained. No difficulty was experienced in trimming all single-engine control forces to zero, and rate of operation of the trim controls was satisfactory about all axes.

3. Determination of Airplane Characteristics With a Hung Extraction Parachute

These tests were accomplished to determine the performance, stability and control characteristics of the CV-2B airplane when towing a hung extraction parachute. Parachutes tested were 15 feet and 22 feet in diameter.

Testing was conducted in steps. Each size chute was first towed behind the airplane on high speed taxi runs. Lift-offs and landings from minimum heights with the chutes fully deployed were accomplished next. Following analysis of this data, chutes were deployed with the airplane airborne at nominal LOLEX heights ranging from four to eight feet. Final tests were accomplished at altitude where the chutes were deployed and towed at various speeds to evaluate the flying qualities of the airplane and to measure the drag force due to the parachutes (See Figure 2, Appendix).

22-Foot Chute

With a 22-foot chute deployed, lift-off could be accomplished, but the airplane would not climb out of ground effect using any combination of power, airspeed and flap setting. This was probably partially due to an oscillating parachute drag vector caused by ground effects on wing and tailplane downwash angles. As the airplane climbed out of ground effect, the parachute rotated downward, causing the airplane to settle toward the ground. Excess power available was not sufficient to offset settling until the airplane had settled back into ground effect, at which time the chute oscillated

upward and the airplane began a new climb cycle. Total effect was that the airplane flew an oscillating flight path (similar to a long period dynamic phugoid maneuver) close to the ground which the pilot was unable to correct (See Figure 2, Appendix). Landing the airplane with the chute deployed required that the pilot "juggle" power and attitude so as to execute a landing flare that was compatible with the oscillations imposed by the chute, i.e., the flare had to be timed so that it would not be disrupted by nose-down pitching caused by the chute. All landings and takeoffs with the chute deployed were completed successfully but required considerable pilot attention.

In addition to the dynamic pitch oscillations, the parasite drag created by the 22-foot parachute caused strong static nose-down pitching moments. These moments were caused by the attachment of the chute at a point approximately five feet below the vertical center of gravity of the airplane. Since the vertical center of gravity is located near the roof of the cargo compartment, it is probable that, in actual service operations, the attachment point would also be located so as to cause nose-down pitching. Analysis of data showed that, with the longitudinal center of gravity of the airplane located near the mid position, static nose-down pitching caused by the chute required varying aft control-stick deflections of from 50 to 100 percent of that available in the control system (See Figure 3, Appendix). Aft stick force required to maintain these varying deflections was approximately 20-25 pounds. Magnitude of the required aft control deflections was unsatisfactory because, in turbulence or with a forward center-of-gravity position, an inadequate control margin would be available to offset the dynamic pitching oscillations described above. Considering the close proximity of the airplane to the ground, a dangerous flight condition could result.

These characteristics indicate that a requirement exists for a device that could be used to obtain an immediate separation of a hung chute from the drop airplane.

<u>15-Foot Chute</u>

With a 15-foot chute deployed, lift-off and climb out of ground effect was achieved in the LOLEX configuration. Transition was then made to the clean configuration (flaps and gear up) to determine clean configuration performance.

Under test day conditions, at a pressure altitude of 2500 feet and a gross weight of 24,000 pounds, it was possible to maintain altitude in ground effect in the LOLEX configuration at 60 knots IAS, using 2000 rpm and 32 inches manifold pressure (a nominal cruise power setting). At approximately Normal Rated Power (2250 rpm and 35 inches manifold pressure), it was possible to maintain altitude out of ground effect at 60 knots IAS. At maximum continuous power (2550 rpm and 42.5 inches manifold pressure), a very limited power-required test showed that a maximum rate of climb of approximately 150 fpm could be obtained at 58-60 knots IAS in the LOLEX configuration. Varying the airspeed more than 3-5 knots caused the rate of climb to deteriorate to zero.

After transitioning to the clean configuration (gear and flaps up), a second power-required test showed that a maximum rate of climb of approximately 200 fpm could be obtained at 72 knots IAS. Varying the airspeed more than 5-6 knots again caused the rate of climb to deteriorate to zero.

This improvement in performance over that obtained with the 22-foot chute was caused by the reduction in chute parasite drag due to the reduced frontal area of the 15-foot chute, which was approximately one-half that of the 22-foot chute.

The marked deterioration in airplane handling qualities that was obtained with the 22-foot chute deployed was not as apparent with the 15-foot chute deployed. This was caused by the reduced chute drag vector effects on longitudinal stability. Consequently, more precise control of the airplane was possible and a larger margin of aft longitudinal control was available to offset dynamic pitching oscillations.

Considering the extremely marginal rates of climb (150-200 fpm) obtained, the light test gross weight (24,000 pounds) and the extreme reduction in range, it is probable that continued flight with a 15-foot chute deployed would be possible only under optimum conditions (i.e., no barriers, short distances and at light gross weights). It is not probable that all these conditions would be satisfied in actual service operations. These considerations indicate that with a 15-foot chute deployed, a requirement exists for a device that could be used to separate the hung chute from the airplane,as previously stated.

Summarizing, extraction chute tow tests showed that there was an unacceptable deterioration in airplane performance, stability and control with a 22-foot chute deployed and that this deterioration, although reduced with a 15-foot chute, was still of sufficient magnitude to warrant the employment of a device that could be used to separate either size chute from the airplane. It is emphasized that these results were for test day conditions only and were, of necessity, based on tests that were limited in scope owing to time available. Variations in airplane gross weight and atmospheric conditions would have a considerable effect on the airplane performance, stability and control characteristics obtained. To determine the effects of a hung chute over a wide range of altitudes, speeds, gross weights and center-of-gravity positions, further engineering testing will be required.

4. LOLEX Drops (High Altitude Tests) (See Table I, Appendix)

Following hung parachute and single-engine testing, sufficient safety-of-flight information was available to commence drops at altitude, using the proposed LOLEX configuration and proposed flight envelope. The purpose of these tests was to evaluate the static and dynamic stability and control characteristics of the CV-2B airplane during the load extraction sequence prior to commencing drops at LOLEX heights

Six air drops of LOLEX loads ranging from 1500 pounds to 4150 pounds were accomplished at an absolute altitude of approximately 1500 feet, at gross weights ranging from 26,600 pounds to 28,300 pounds and at indicated airspeeds ranging from 67 to 100 knots. Transient dynamic and static response of the airplane to load extraction was recorded with an oscillograph, and the data obtained was correlated with qualitative pilot observations to determine the suitability of the flying qualities of the airplane during the drop sequence.

Results showed that the static and dynamic flying qualities of the airplane during the LOLEX sequence were satisfactory. No difficulty was experienced in stabilizing at the drop airspeeds in the LOLEX configuration. Dynamic response of the airplane during extraction was found to be proportional to the center-of-gravity change of the airplane with load extraction. The magnitude of this response was negligible when center-of-gravity changes were small

and increased when center-of-gravity changes were large. At no time, however, was the magnitude of the response unsatisfactory. Analysis of oscillograph data showed that maximum transient pitching was ± three degrees with large center-of-gravity changes, that the pitching occurred within approximately two seconds and damped completely in three-quarters to one cycle. Due to the frequency of the oscillation, pitching occurred and damped itself out before any pilot control inputs were made. The frequency, amplitude and self-damping characteristics of this pitching oscillation were such that no undesirable airplane attitudes were obtained and no crew discomfort was experienced.

Static longitudinal trim changes which were obtained following termination of transient pitching varied in direction with the direction of the center-of-gravity shift (fore or aft). All trim changes obtained were satisfactory for all center-of-gravity variations tested. Maximum trim change obtained was eight pounds nose-down and was well within pilot force capabilities until re-trimming could be accomplished. Re-trimming, when required, was easily obtained and no difficulty was experienced in maintaining control of the airplane.

These test results showed that stability and control characteristics of the CV-2B during and following extraction were satisfactory for the conditions tested and were compatible with operations at LOLEX heights.

5. Verification of Proposed Minimum LOLEX Approach Speeds Based on Single-Engine Capability (LOLEX Height Tests)

Before proceeding with actual LOLEX drops at minimal heights, it was necessary to validate the results of the high-altitude single-engine tests at actual LOLEX heights to determine whether ground effects would cause any significant variations in airplane performance, stability and control. In addition, these tests were utilized to determine the adequacy of the single-engine procedures (except for load jettisoning) that had been previously developed.

Utilizing the proposed LOLEX configurations and flight envelope, abrupt chops of the critical (left) engine were executed at gross weights ranging from 23,500 pounds to 28,500 pounds at

various center-of-gravity positions. These chops were accomplished at nominal LOLEX heights ranging from two to ten feet with the airplane in wings-level, stabilized flight.

No difficulty was experienced in employing the "zoom" technique and it was found that owing to the improved attitude references available when close to the ground, improved attitude control of the airplane was obtained, thus enhancing the pilot's ability to attain maximum height without decelerating to speeds below the minimum control speed. Additionally, height obtained during the "zooms" increased because of ground effects on the lift/drag characteristics of the airplane; and heights of approximately 75 to 125 feet were attained at the top of the "zoom" maneuver.

A five-second delay was employed on all runs between the completion of the "zoom" maneuver and the initiation of the single-engine procedures. The proposed cockpit procedures em... following the "zoom" were found to be effective and easy to perform. It was determined that, employing these procedures, consistent, single-engine recoveries could be made using no unusual pilot techniques at engine failure airspeeds down to five knots below those recommended in this report. At speeds below this five knot margin, excessive pilot technique was required to retain control of the airplane while preventing ground contact.

Particular note was made of the height profile followed by the airplane during the period between "zooming" and the establishment of stabilized single-engine climb. These observations showed that the pilot was consistently able to maintain a height of at least fifty feet while employing cockpit procedures.

6. Drops at LOLEX Heights (See Table I, Appendix)

As a result of buildup testing described in foregoing paragraphs, sufficient safety-of-flight, performance, stability and control data were obtained to proceed with actual LOLEX drops to verify the suitability of the proposed configurations, flight envelope and procedures.

Eight drops of LOLEX loads ranging from 1500 pounds to 4150 pounds were accomplished at wheel heights ranging from two

to ten feet. Both straight-in and tactical LOLEX approaches were utilized for these drops. To verify the validity of the single-engine procedures, an engine was failed during the load extraction sequence on the last drop. On all drops, airplane characteristics and pilot control inputs were recorded using an oscillograph, yaw and angle-of-attack strings and sensitive cockpit instrumentation. All drops were photographed by a ground based Fairchild Flight Analyzer camera and by a movie camera mounted in a chase airplane. Load trajectory during each drop was recorded by two movie cameras mounted in the cargo compartment of the test airplane.

a. Straight-in LOLEX Approaches

A rectangular pattern similar to a landing pattern was utilized to set up the approach for the LOLEX drop. Downwind leg was flown at a height of approximately 800 feet above ground level. Turn onto base leg was accomplished and descent to approach height was initiated. The airplane was then placed in the LOLEX configuration and turn onto the final run heading was accomplished at a distance of approximately one to two miles from the drop point. After establishing the airplane at the desired height (approximately five feet), final load restraints were removed and power was manipulated to obtain the desired drop speed.

Flying qualities of the airplane during the approach run were generally satisfactory, with two exceptions:

(1) Difficulty was experienced in maintaining a precise drop height during the approach run for the following reasons:

(a) with the flaps deflected (either 7 or 15 degrees), the characteristics of the type of airfoil section utilized in the CV-2B are such that small changes in pitch attitude produce relatively large changes in lift and, therefore, drop height; and

(b) in the LOLEX configuration and speed range, longitudinal sensitivity of the CV-2B is weak, thus making the changes in drop height described in the foregoing difficult to control. In turbulent air or when approaching a drop point over

rapidly rolling terrain, therefore, it is probable that some difficulty would be experienced in maintaining precise drop heights within approximately 10 to 15 feet of the desired height.

(2) High approach speeds (100 knots IAS) at minimum height required additional pilot attention and produced a hurried, uncomfortable feeling owing to the increased relative motion over the ground, the decrease in time available to make adjustments in flight path and the increased difficulty in estimating the point at which to actuate the extraction mechanism. At the recommended approach speeds, however, this difficulty was not experienced.

Approaching the drop point, the copilot actuated the pendulum release switch to initiate load extraction. The switch, located on the left side of the instrument panel, required the copilot to assume an uncomfortable attitude in which he could observe the drop point only with difficulty. Since it is not practical for the pilot to actuate the switch while flying the airplane, this switch should be relocated to a position where copilot actuation would be possible without necessitating a change in his sitting position.

A typical LOLEX time history recorded on an oscillograph is presented in Figure 4, Appendix. The figure shows that extraction did not begin until approximately four seconds after the pendulum release had been activated. Most of the lag in extraction was caused by the time required for the extraction-chute package to free fall clear of the airplane and deploy. Assuming a nominal approach speed of 80 knots IAS at sea level on a standard-day, with no wind, the airplane would be approaching the drop point at the rate of 135 feet per second. In the four-second interval, the airplane would cover a distance of 540 feet. At this distance, it was difficult to estimate the required time/distance lead to achieve pin-point drop accuracy. A reduction in required lead time is desirable and would probably improve drop accuracy.

Dynamic and static response of the airplane to load extraction was unchanged from that obtained at altitude and was satisfactory. Dynamic oscillations occurred within approximately two seconds and damped in one cycle. No difficulty was experienced in maintaining height above the ground during these oscillations and, in fact, approximately 5 to 15 feet were gained as the airplane

"ballooned" following load extraction. Static trim changes following the dynamic oscillations were nose down owing to the forward shift in center of gravity but were of very small magnitude so that the pilot had no difficulty maintaining attitude until re-trimming could be accomplished.

Following load extraction, both throttles were applied to takeoff power settings and a climb was established. No difficulty was experienced in this procedure when initiating the climb from the recommended approach speeds. Landing gear and flaps were then raised and the airplane was placed in the clean climb configuration for the remainder of the climb-out.

b. Tactical LOLEX Approaches

Two tactical approaches were completed during this evaluation. These approaches were executed to determine the suitability of the proposed configurations and the proposed flight envelope under simulated tactical conditions.

For these approaches, it was assumed that 50-foot barriers were located on both sides of the drop point. The technique used was to stabilize the airplane in the LOLEX configuration at the desired approach speed while maintaining a 50-foot (tree-top) height on the final approach run until the barrier was cleared. Maintaining a constant attitude (and, therefore, airspeed), throttles were then rapidly retarded to the idle position and the pendulum release switch was activated to initiate the extraction sequence as the airplane commenced its descent. Extraction of the load was obtained as the airplane descended to LOLEX height. Takeoff power was then applied and climb-out was commenced at the climb speed recommended in Reference f, Section I, paragraph 1 followed by landing gear and flap retraction.

Using this technique, it was necessary to determine the point in the approach at which to initiate the extraction sequence to obtain load extraction as the airplane reached drop height (assuming that minimum field length was available so that extraction was desired as soon as possible). It was found that approximately four to five seconds were required to descend from 50 feet to a nominal LOLEX height so that, since the extraction sequence also required four to five seconds, initiating the sequence immediately following throttle retardation at 50 feet, produced the desired result.

The flight profile of the airplane during the first of these two drops is shown in Figure 5, Appendix. Examination of the figure shows that extraction was initiated as the airplane descended through 40 feet, 90 feet after passing the barrier and 610 feet in front of the target. The airplane continued to descend until a height of 12 feet was reached at a point 100 feet in front of the target. Height was then maintained essentially constant until load extraction, after which a climb was initiated using takeoff power coupled with simultaneous retraction of landing gear and flaps. Total distance required for the approach over the 50-foot barrier, extraction of the load and climb over the 50-foot barrier was 1460 feet. It is emphasized that this performance is given for test day conditions only and that variations in gross weight, approach speed and ambient atmospheric conditions would cause significant changes in these results. Extensive testing would be required to determine minimum LOLEX field lengths for all combinations of weight, speed and altitude within the capability of the airplane.

Flying qualities of the CV-2B during this type of approach were satisfactory except that some difficulty was experienced in terminating the descent to the drop point at exactly the desired LOLEX height and airspeed. This difficulty was caused by a combination of airplane inertia, pilot depth-perception limits, the longitudinal response characteristics of the CV-2B and high throttle break-out forces, which made the required rapid-power application difficult to execute accurately and smoothly. It is probable, therefore, that use of this technique in LOLEX service operations would result in some variation in drop airspeed and drop height from that intended. Small variations in airspeed at the drop would probably not affect drop results. Further testing would be required to determine the maximum variations in drop height that could be tolerated without imposing excessive damage to the load.

c. Engine Failure During the LOLEX Extraction

This test was executed under conditions that were determined to be the most critical from the standpoint of performance, stability and control (See Table I, Appendix). On the last drop of the test series, an engine was failed to determine the validity of the single-engine procedures that had been developed.

The left engine was failed over the drop point at a height of approximately 5 feet as the load began to extract from the airplane. Following the extraction a "zoom" was initiated to gain additional height. The evaluating pilot next delayed approximately five seconds before initiating single-engine procedures. Proposed single-engine procedures were then executed and a single-engine climb was established.

Response of the airplane following the engine failure was very satisfactory. Nose-up dynamic pitching, caused by the rearward shift in center of gravity as the load moved aft, offset nose-down pitching caused by the power loss so that no apparent trim change was obtained. As the load left the airplane, "ballooning" occurred and aided the pilot in executing the "zoom" maneuver. Approximately 100 feet were obtained as the airplane was "zoomed" to an airspeed 5 knots above the appropriate single-engine minimum control speed for the reduced weight. At the top of the "zoom", an aft-stick force of approximately 3 to 5 pounds was required to maintain attitude and was satisfactory. No difficulty was experienced in controlling the airplane.

Following the deliberate delay in pilot response, the proposed single-engine procedure was initiated. Both throttles were applied to takeoff power settings, feathering was accomplished and the landing gear was retracted. No difficulty was experienced in accomplishing this procedure. Single-engine climb was then established and the flaps were retracted in steps, allowing acceleration to the recommended clean configuration climb speed while maintaining a positive rate of climb.

This test was tracked with a theodolite by ground-based personnel. Their observations showed that the load left the airplane cleanly at a height of approximately 12 feet during the early stage of the "zoom" maneuver and that airplane height above the ground following the "zoom" was maintained in excess of 50 feet during the remainder of the single-engine sequence.

In summary, this final test series validated the suitability of the proposed single-engine procedures and the performance, stability and control characteristics of the CV-2B airplane during

operations in the recommended LOLEX configuration and flight envelope. These results were obtained for testday conditions only. Variations in gross weight, airspeed and altitude would significantly affect the single-engine performance obtained. Further testing would be required, therefore, to establish performance for all combinations of these parameters.

Richard J. Kennedy Jr.
RICHARD J. KENNEDY, JR.
Lieutenant Colonel, TC
Commanding

1 Incl
Appendix

TABLE I

LOLEX FLIGHT SAFETY TEST DROP SUMMARY

CV-2B S/N 62-4175

DATE 1964	TEST	EXTRACTION CHUTE DIAMETER ~FEET~	INDICATED AIRSPEED ~KNOTS~	FLAP SETTING ~DEG~	GROSS WEIGHT PRE-DROP ~LB~	LOAD WEIGHT ~LB~	CENTER OF GRAVITY ~PERCENT MAC~	
							PRE-DROP	POST-DROP
17 MARCH	ALTITUDE EXTRACTION	15	85	15	27400	1500	33.9	30.8
18 MARCH	ALTITUDE EXTRACTION	15	69	15	27200	1500	34.7	31.9
18 MARCH	ALTITUDE EXTRACTION	15	67	15	27100	1500	38.7	32.7
20 MARCH	ALTITUDE EXTRACTION	22	69	15	26600	2500	32.5	31.6
21 MARCH	ALTITUDE EXTRACTION	22	79	15	27800	4150	34.3	31.4
25 MARCH	ALTITUDE EXTRACTION	22	100	7.5	28300	4150	38.5	31.5
26 MARCH	LOLEX - LEVEL APPROACH	15	80	15	25700	1750	34.3	31.8
26 MARCH	LOLEX - LEVEL APPROACH	15	68	15	25600	1750	34.3	31.5
26 MARCH	LOLEX - LEVEL APPROACH	15	102	7.5	25400	1750	34.2	31.1
27 MARCH	LOLEX - LEVEL APPROACH	15	76	15	27100	2750	35.6	30.0
27 MARCH	LOLEX - LEVEL APPROACH	15	99	7.5	26600	2750	36.8	30.8
27 MARCH	LOLEX - TACTICAL APPROACH	15	78	15	26200	2750	36.6	30.6
3 APRIL	LOLEX - TACTICAL APPROACH	22	90	7.5	28000	4150	38.0	31.0
3 APRIL	LOLEX - ENGINE CHOP	22	89	7.5	27800	4150	37.9	31.1

NOTE

ALL EXTRACTIONS WERE CONDUCTED WITH

1. RAMP LEVEL
2. CARGO DOOR OPEN
3. LANDING GEAR DOWN

[redacted]

FIGURE NO 1

LOLEX SAFE SINGLE ENGINE AIRSPEEDS

CV-2B S/N 62-4175

CONFIGURATION

1. LANDING GEAR DOWN
2. FLAP SETTING - AS NOTED ON GRAPH
3. POWER FOR LEVEL FLIGHT AT ENGINE-FAILURE
4. PROPELLER CONTROL - TAKE-OFF RPM SETTING
5. RAMP DOOR - LEVEL
6. CARGO DOOR - OPEN
7. AUTOFEATHERING - OFF

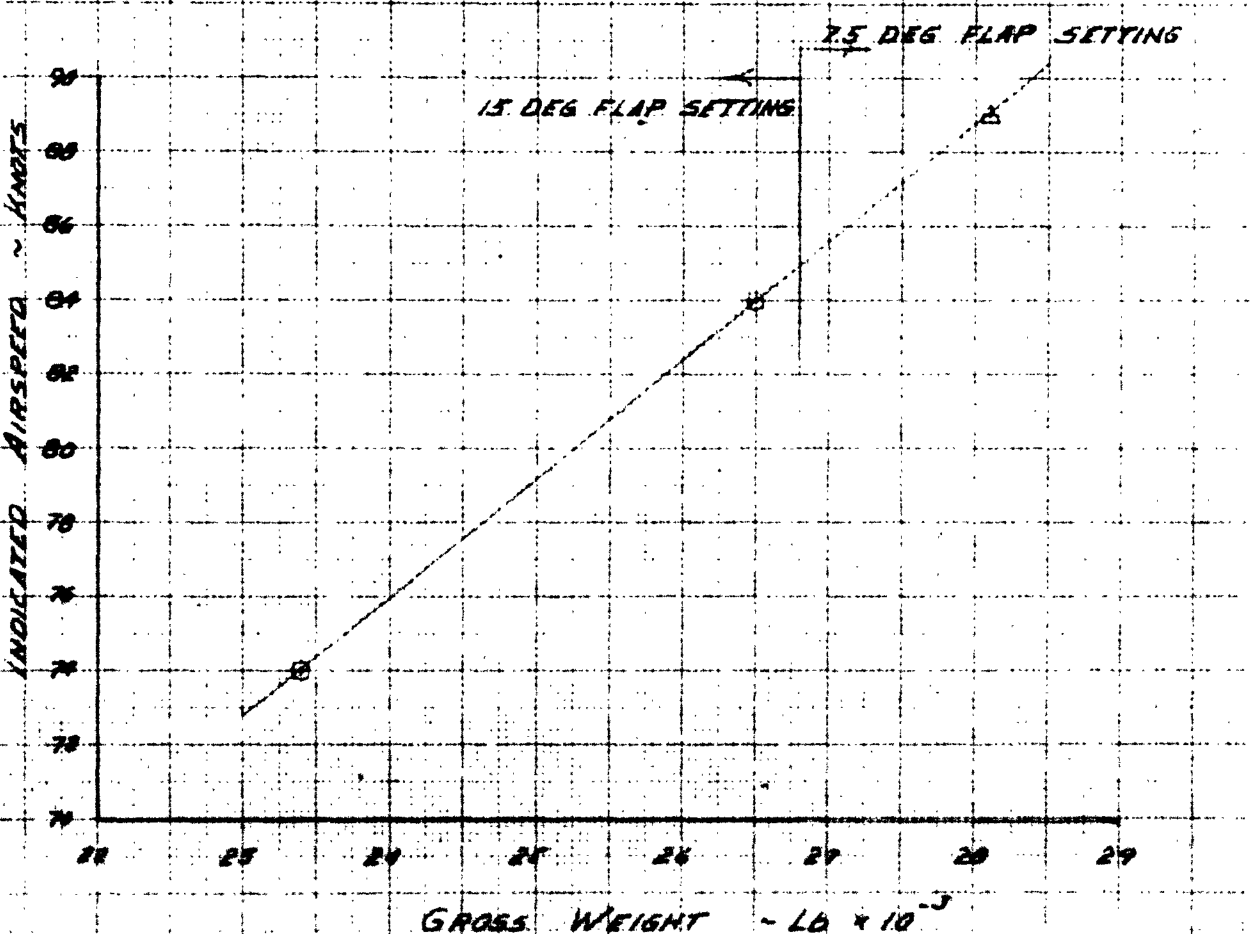
SYMBOL	FLAP SETTING
O	15 DEG.
Δ	7.5 DEG.

NOTE

TEST DATA POINTS SHOWN ON GRAPH CONDUCTED AT:

AVG PRESSURE ALTITUDE = 2300 FT

AVG TEMPERATURE = 2°C



[redacted]

[redacted]

FIGURE NO 2

LOLEX EXTRACTION LINE TENSION FORCES WITH A DEPLOYED EXTRACTION CHUTE

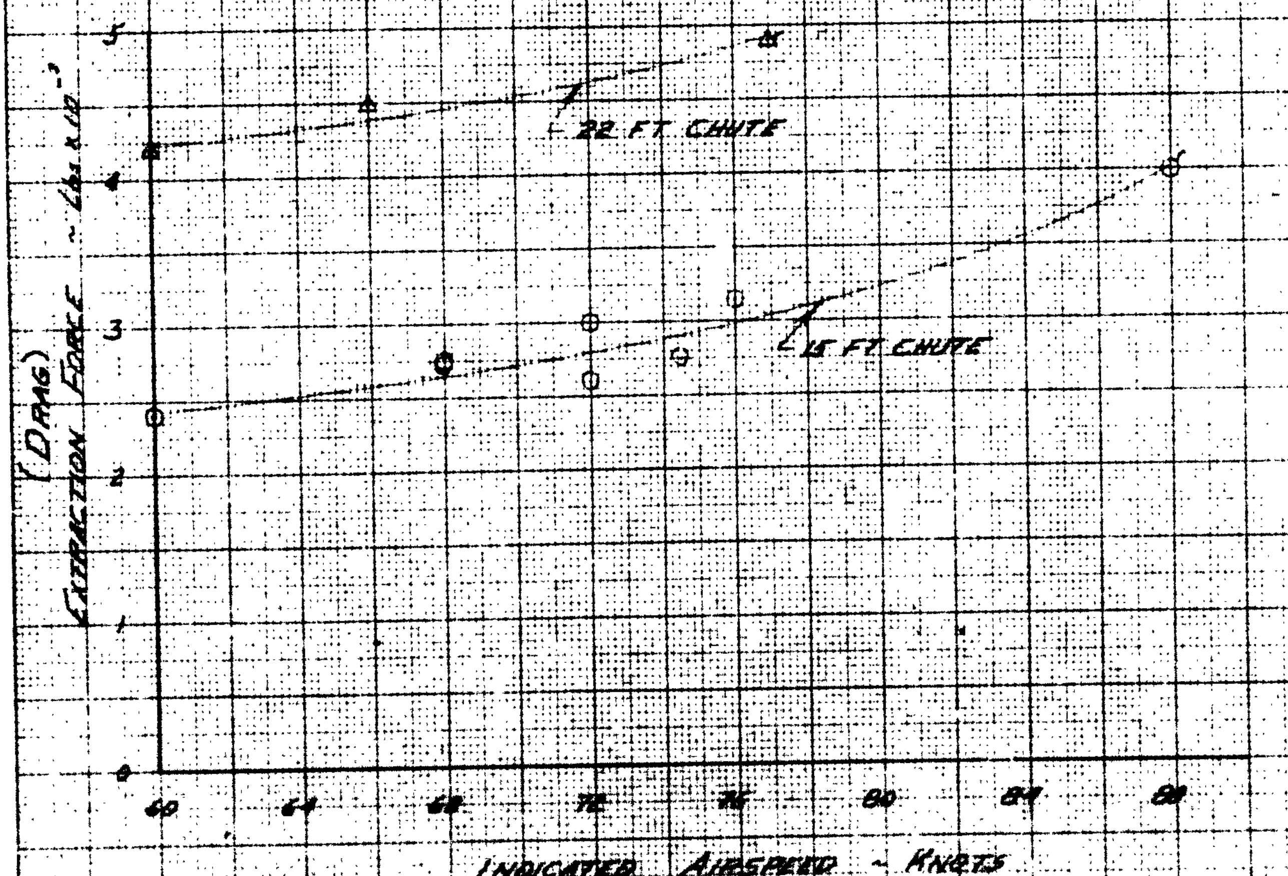
CV-2B — S/N 62-4175.

FLAPS = 15 DEGREES
LANDING GEAR DOWN
MAXIMUM CONTINUOUS POWER
RAMP DOOR LEVEL
CARGO DOOR OPEN

NOTE: WITH THE 22 FT CHUTE DEPLOYED IT WAS IMPOSSIBLE TO CLIMB OUT OF GROUND EFFECT A PHUGOID OSCILLATION WAS ENCOUNTERED AND THE AIRSPEEDS PRESENTED REPRESENT AVERAGE VALUES

SYMBOL	CHUTE DIAMETER
○	15 FT.
△	22 FT

FLAGGED SYMBOLS DENOTE DESCENTS



[redacted]

[redacted]

FIGURE No 3

[illegible] 22 FOOT EXTRACTION CHUTE DRAG TEST
[illegible] S/N [illegible]

CONFIGURATION
1 LANDING GEAR DOWN
2 FLAP SETTING - 15 DEGREES
3 POWER SETTING - TAKE-OFF
4 PROPELLER CONTROL - TAKE-OFF RPM
5 RAMP DOOR - LEVEL
6 CARGO DOOR - OPEN

INDICATED AIRSPEED [illegible] (AVG) ~ KNOTS
GROSS WEIGHT 24000 LB

NOTE
IT WAS IMPOSSIBLE TO CLIMB OUT OF GROUND EFFECT WITH THE 22 FOOT CHUTE DEPLOYED.

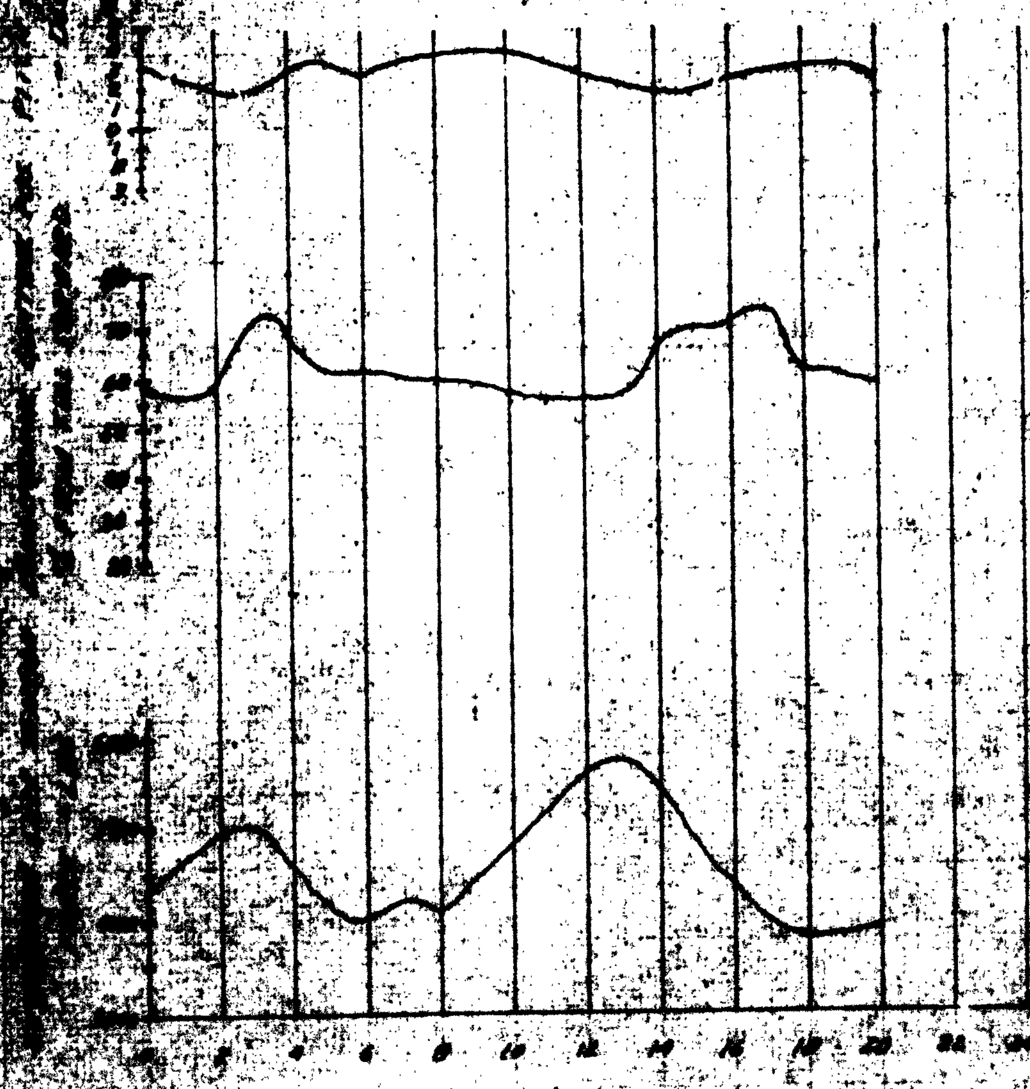


Figure No 4

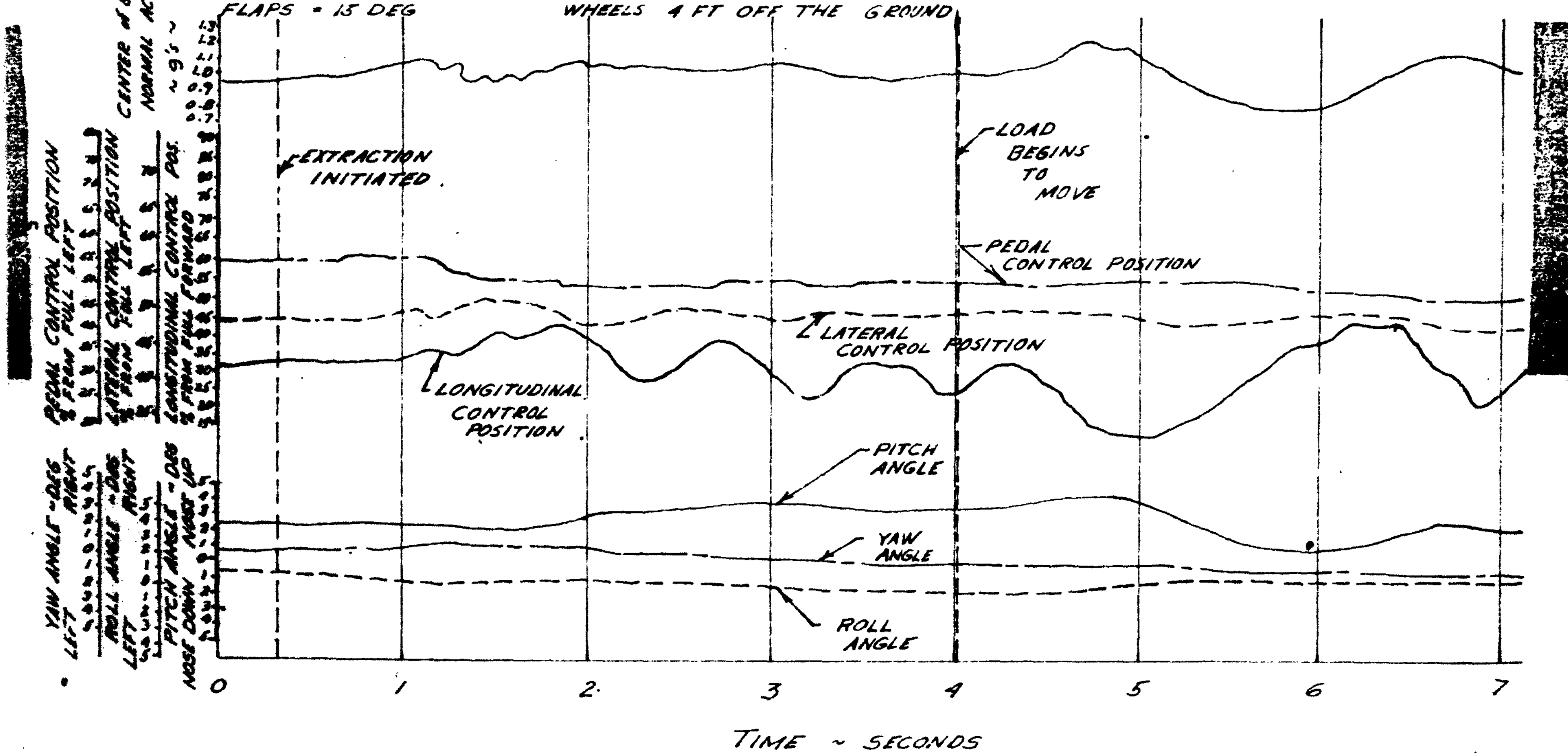
LOLEX Time History

CV-28 SIN62-4175

2750 LB LOAD

INDICATED AIRSPEED AT DROP = 76 KNOTS
PRESSURE ALTITUDE = 2100 FT
TEMPERATURE = 5° C

GROSS WEIGHT BEFORE DROP = 27,100 LB
CENTER OF GRAVITY BEFORE DROP = 35.6% MAC
CENTER OF GRAVITY AFTER DROP = 30.0% MAC



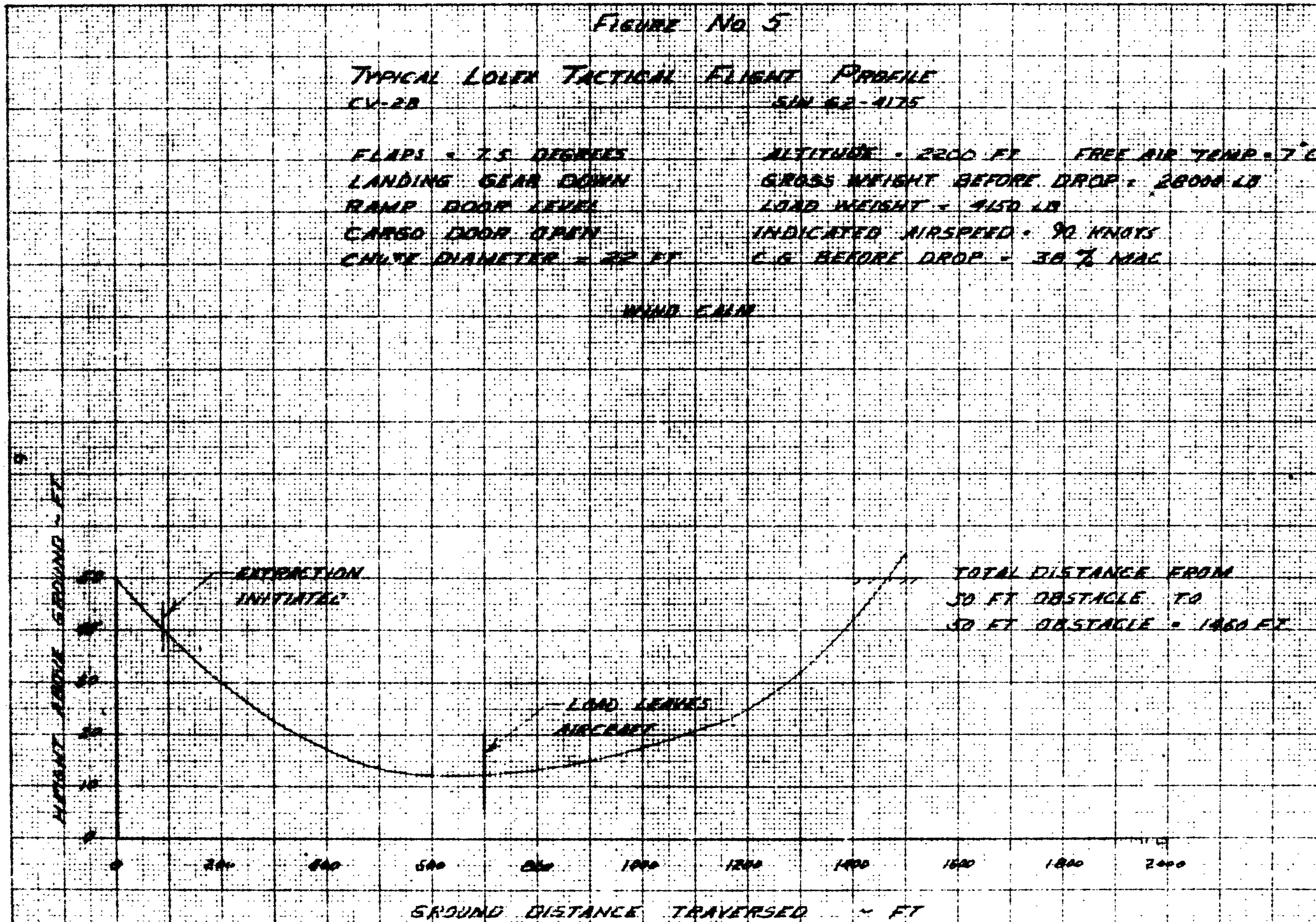


FIGURE NO 5
TYPICAL LOLEX TACTICAL FLIGHT PROFILE
CV-2B
S/N 62-4175
FLAPS = 7.5 DEGREES
LANDING GEAR DOWN
RAMP DOOR LEVEL
CARGO DOOR OPEN
CHUTE DIAMETER = 22 FT
ALTITUDE = 2200 FT
FREE AIR TEMP = 7°C
GROSS WEIGHT BEFORE DROP = 28000 LB
LOAD WEIGHT = 4150 LB
INDICATED AIRSPEED = 90 KNOTS
C.G. BEFORE DROP = 38 % MAC
WIND CALM
EXTRACTION INITIATED
LOAD LEAVES AIRCRAFT
TOTAL DISTANCE FROM 50 FT OBSTACLE TO 50 FT OBSTACLE = 1460 FT
HEIGHT ABOVE GROUND ~ FT
0
10
20
30
40
50
0
200
400
600
800
1000
1200
1400
1600
1800
2000
GROUND DISTANCE TRAVERSED ~ FT

APPENDIX X -

ENGINEERING TEST REPORT,

YUMA PROVING GROUND

HEADQUARTERS
YUMA PROVING GROUND
Yuma, Arizona 85364

FINAL REPORT OF
ENGINEERING TEST OF
LOW LEVEL EXTRACTION TECHNIQUE (LOLEX)
FROM CV-2B AIRCRAFT

USATECOM PROJECT NO.: 4-4-7475-02

FOR THE COMMANDER:

FLOYD E. WATTS
Chief, Missions and Plans

ABSTRACT

An engineering test of the Low Level Extraction Technique (LOLEX) from a CV-2B aircraft was conducted by and at Yuma Proving Ground, Arizona.

Within the limits of precision normally attainable with consideration to derived flight safety and operational parameters, load survivability is comparable to that of conventional air delivery systems employing retardation parachutes.

The LOLEX method of air delivery is reliable for use when performed within the recommended flight safety and operational parameters.

Load survivability is sufficiently high for operational use.

The LOLEX method of air delivery can be performed without danger of compromise when utilizing standard air type items and system components.

The standard pendulum release system installation in the CV-2B aircraft is not sufficiently reliable for use in LOLEX operations.

The LOLEX flight safety and operational parameters derived for, and employed in, the air delivery engineering test program be used as basis for establishment of standard LOLEX techniques and operational procedures.

The aircraft pendulum release system be redesigned using field modification as basis.

A follow-on LOLEX development and test program be established to increase load survivability, maximize the CV-2B LOLEX capability and minimize safety hazard to crew and aircraft.

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SECTION 1 - GENERAL

1.1 REFERENCES

a. Letter, AMCRD-DM-E, Headquarters, U. S. Army Materiel Command, 18 November 1963, Subject: New Air Delivery Techniques for CV-2B Airplane.

b. Letter, SDEG-MR, Headquarters, U. S. Army Combat Developments Command, 14 October 1963, Subject: New Air Delivery Techniques for CV-2B Airplane.

c. Letter, AMCRD-DM-E, Headquarters, U. S. Army Materiel Command, 24 October 1963, New Air Delivery Techniques for CV-2B Airplane, with 1st Indorsement, ATUTR-AVN, Headquarters, U. S. Continental Army Command, 1 November 1963.

1.2 AUTHORITY

a. Letter AMSTE-BG, Subject: "Directive for Integrated Engineering/Service Test of Low Level Extraction Technique (LOLEX) from CV-2B Aircraft, USATECOM Project No. 4-4-7475" dated 29 November 1963.

b. Coordinated Plan of Test, USATECOM Project No. 4-4-7475, "Integrated Engineering/Service Test of Low Level Extraction System (LOLEX) from CV-2B Aircraft," DA Project No. 1K141812D183-37 CDOG Par 939b(14), dated 9 January 1964.

1.3 OBJECTIVES

a. To determine reliability for U. S. Army use of LOLEX method of air delivery using the CV-2B aircraft with particular emphasis upon load survivability.

b. To obtain sufficient engineering data to establish recommended procedures for use with the LOLEX system with specific attention to rigging procedures and effect of aircraft flight characteristics and parameters.

1.4 RESPONSIBILITIES

Yuma Proving Ground, Arizona is designated a supporting test agency with primary interest in the engineering portion of the test as pertains to the air delivery systems used and loads delivered.

Yuma Proving Ground was responsible for conduct of tests No. 2 and 3 and participated in tests No. 1 through 8 as outlined in the Coordinated Plan of Test.

1.5 DESCRIPTION OF MATERIEL

The Low Level Extraction System (LOLEX) is an adaptation of the standard air drop extraction and air unloading kit systems. Extraction is accomplished while the aircraft is flying at the lowest possible altitude and at reduced speed. This system eliminates the necessity for recovery (cargo) parachutes. The extraction parachute serves as a deceleration force to reduce the forward momentum of the load during descent and after ground impact. LOLEX was developed for delivery of army supplies and equipment which are within the capability of the CV-2B aircraft.

1.6 BACKGROUND

The requirement for a low altitude air drop system for supplies and equipment is stated in CDOG Paragraph 939b(14).

During the period June to August 1962, an extraction system using ground-based deceleration devices was explored. During the period January to March 1963, U. S. Army Natick Laboratories, Natick, Massachusetts, in conjunction with U. S. Army Airborne, Electronics and Special Warfare Board, Fort Bragg, North Carolina, and other interested army agencies, conducted an expedited evaluation of two ground-based extraction systems. Testing was terminated when it was ascertained that ground-based extraction systems presented unacceptable safety hazards to the air crews and aircraft.

During Exercise Swift Strike III, August 1963, a detachment from the Airborne Department, U. S. Army Quartermaster School, Fort Lee, Virginia, in coordination with the 187th Airplane Transport Company, 10th Air Transport Brigade, 11th Air Assault Division, Fort Benning, Georgia, demonstrated Low Level Extraction Systems. Since August 1963, other army units and agencies have used the system. To date, the system has not been tested to determine its suitability for army use nor have standard procedures and techniques been developed, approved and published.

Upon receipt of test authorization from U.S. Army Test and Evaluation Command, U.S. Army Aviation Test Activity conducted engineering tests to determine flight safety and operational parameters for the CV-2B aircraft when employed in LOLEX operations.

1.7 FINDINGS

1.7.1 GENERAL

Fluctuation of meteorological wind conditions, variation in drop zone characteristics and variation in type air delivery loads negate performance of LOLEX operation in a truly precision or precise manner. Within the limits of precision normally attainable with consideration to derived flight safety and operational parameters, load survivability is comparable to that of conventional air delivery systems employing retardation parachutes.

1.7.2 LOAD STABILITY

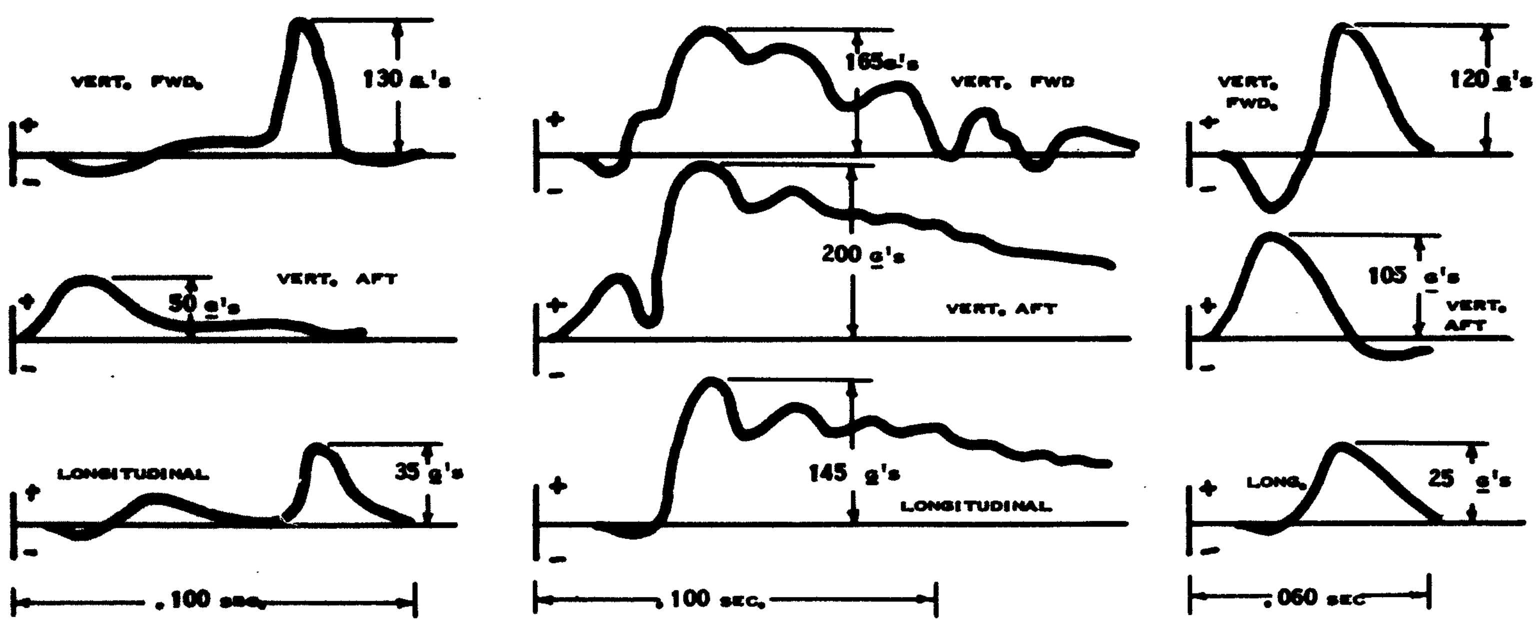
During descent, and with reference to the ground, the LOLEX load maintains significant forward speed. The load maintains good lateral stability, inherently, unless the aircraft had been in transient instability during extraction and tip-off. The load may or may not attain a near-stable pitch attitude before, or at, touchdown, depending on factors to be discussed in Appendix II. Load survivability is more predictable when the load has a specific stable pitch attitude at touchdown.

1.7.3 IMPACT CHARACTERISTICS

On impact, the g forces due to horizontal speed and/or load rotation are significant factors in load survivability (Fig. 1). The minimization of these forces and/or their effects is essential and will be discussed in Appendix II.

1.7.4 DROP ZONE LENGTH

A minimum length of 400 to 500 feet should be relatively level and cleared of airspace obstructions - half of which should be as clear and level as practical, based on effort required versus load survivability.



Typical g Forces For Nose-High Load Impact.
Drop No. 4 (ATB No. 324)
Drop Height 7.5 ft.
(Time reads from left to right.)

Typical g Forces For Flat Load Impact Attitude.
Drop No. 8 (ATB No. 336)
Drop Height 10.5 ft.

Typical g Forces For Moderate Nose-up Load Impact Attitude.
Drop No. 2 (ATB No. 323)
Drop Height 10.5 ft.

FIGURE 1

1.7.5 DROP HEIGHT

The drop height for loads in the 4000-pound range should not be over 15 feet (11 feet of gear-down clearance) graduating downward to the minimum feasible height. Preferable drop heights are 8 or 10 feet (4 or 6 feet of gear-down clearance) for rough surfaces, and 7 or 8 feet (3 or 4 feet gear-down clearance) for flat or smoothly undulating surfaces.

1.7.6 AIRCRAFT ATTITUDE SPEED AND FLIGHT PATH

The preferable aircraft attitude speed is 80 knots IAS unless gross weight requires higher speed; the preferable flight path is straight, level and steady, with cargo floor horizontal and ramp position level. Crab rather than side-slip when necessary to follow drop zone surface contours in cross wind. The load will not sideswipe aircraft if the parachute pulls slightly to one side. As an expedient only, use nose-up attitude for high drop heights and faster speeds (85 to 90 knots) for heavier loads with centered or forward center of gravity.

1.7.7 AIR DELIVERY SYSTEM CHARACTERISTICS

Optimum platform length is 96 inches long and 70 inches wide for weight ranges tested. Load should be distributed uniformly when feasible, with the center of gravity centered laterally, approximately 6 inches aft of center of platform, and as low as practical. Attachment point of the extraction line should be at one end of the load, approximately 6 inches higher than the center of gravity. Extraction clearance is questionable for silhouettes over 60 inches high.

1.7.8 EXTRACTION PARACHUTE

A 22-foot ringslot extraction parachute should be used for weights of 1000 to 4000 pounds and a 15-foot ringslot extraction parachute, unreefed optional, for loads of 1000 to 2000 pounds if over 50 inches high, at aircraft speeds of 85 knots or more.

1.7.9 EXTRACTION PARACHUTE PENDULUM RELEASE SYSTEM

The pendulum release system as originally installed in the CV-2B aircraft is not sufficiently reliable for consistently satisfactory LOLEX operations, requiring reversal and field modification of the release hook as shown in Figure 2.

NOTE:

1. This modification is a field expedient for test use <u>only</u>. Not to be used for service use.
2. Effects of Modification:
   - a. Pendulum length increased by $9\frac{1}{2}$".
   - b. Point of rotation moved aft $9\frac{1}{2}$".
   - c. Angle of departure decreased by 5.6°.
   - d. Additional modification: Bomb Shackle was reversed, and pulley added for manual release.

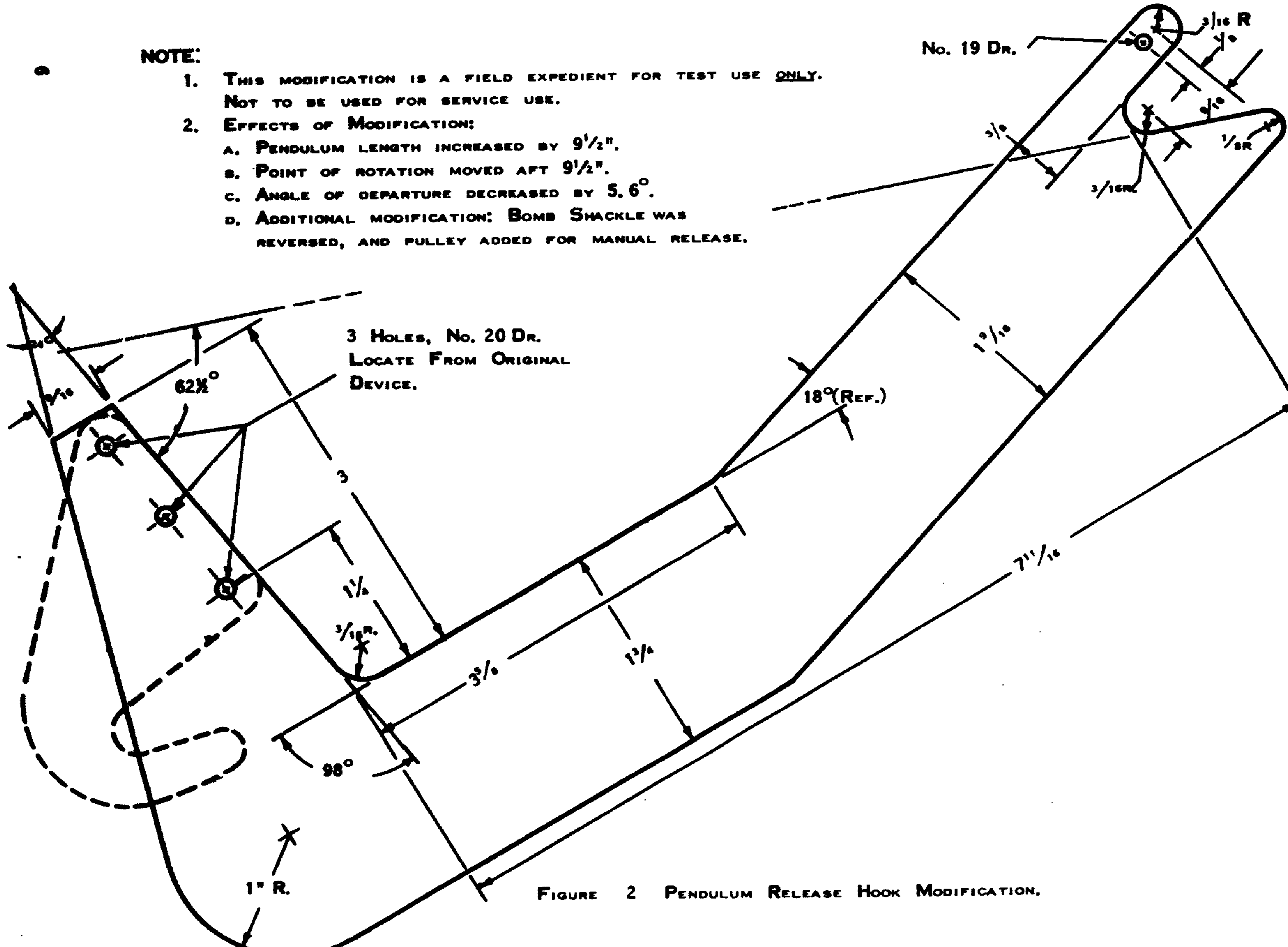


Figure 2 Pendulum Release Hook Modification.

1.8 CONCLUSIONS

a. The LOLEX method of air delivery is reliable for use when performed within the recommended flight safety and operational parameters.

b. Load survivability is sufficiently high for operational use.

c. The LOLEX method of air delivery can be performed without danger of compromise when utilizing standard air type items and system components.

d. The standard pendulum release system installation in the CV-2B aircraft is not sufficiently reliable for use in LOLEX operations.

1.9 RECOMMENDATIONS

a. The LOLEX flight safety and operational parameters derived for, and employed in, the air delivery engineering test program be used as basis for establishment of standard LOLEX techniques and operational procedures.

b. The aircraft pendulum release system be redesigned using field modification as basis.

c. A follow-on LOLEX development and test program be established to increase load survivability, maximize the CV-2B LOLEX capability and minimize safety hazard to crew and aircraft.

SECTION 2 - DETAILS OF TEST

2.0 INTRODUCTION

All air delivery engineering tests were conducted within the aircraft flight safety and operational parameters established by U. S. Army Aviation Test Activity as a result of tests conducted by them at Edwards Air Force Base, California, with assistance from Yuma Proving Ground in the air delivery system area.

The purpose of specific tests varied throughout the conduct of 27 air drop tests conducted at Yuma Proving Ground, as indicated on the general data sheets for each test which are included in Appendix I.

U. S. Army CV-2B aircraft, serial No. 24175, was employed in conduct of all air drop tests.

2.1 METHOD

2.1.1 GENERAL

Standard air-type items and system components, without modification, were used in air delivery systems employed in conduct of tests to gain load survivability data. Electronic and optical instrumentation systems were used for accrual of engineering data necessary for evaluation and analysis of LOLEX method of air delivery under test.

2.1.2 TEST EQUIPMENT

2.1.2.1 Platform

All tests were made using 70-inch wide combat expendable platforms. Basic length was 96 inches. Longer platforms were used for special tests concerned with tip-off behavior and clearance during extraction, and for breakaway vehicle deliveries.

2.1.2.2 Test Load

A steel test load frame 62-1/4 by 90 inches, was used for all tests except vehicle deliveries. Five hundred-pound steel load blocks were installed inside the frame, to provide the required load characteristics for each test.

2.1.2.3 Rigging

Standard 15- and 22-foot ringslot extraction parachutes and 60-foot extraction lines were used for all tests. Standard rigging procedures and materials were used, including paper honeycomb under the loads.

2.1.2.4 Drop Zone

The primary drop zone for a fully instrumented test was a hard, flat, gravel taxiway. Additional drop zone areas were used to provide rough, uncleared, sandy surfaces; furrowed bare earth surfaces with the furrows running in the direction of the flight path; and undulating bare earth surfaces with furrows running at 45 degrees to the flight path.

2.1.3 CONDUCT OF TEST

Air drop tests were made in weight ranges of 1260 to 3800 pounds. Drop height was varied between 2 and 10 feet of gear-down clearance. Aircraft speed was varied between 75 and 88 knots IAS.

Three of the drops were special purpose tests using breakaway vehicle loads.

On one drop the extraction parachute failed to clear the aircraft and fouled on the ramp. The parachute subsequently became unfouled, and a normal extraction occurred several miles from the drop zone.

2.2 INSTRUMENTATION

Two triaxial accelerometers were installed on the steel test frame (load). A displacement meter was installed in the aircraft to measure load movement during extraction. A strain gage link was installed in the extraction line to obtain extraction forces. Two 7-channel radio telemetry transmitting units and a ground-based mobile receiver and recording system were used to record data from the aircraft and from the descending load.

Four fixed synchronized velocity-acceleration cameras (60 fps), 2 mobile cameras (400 fps), and one on-board camera (400 fps) were used to obtain photographic coverage.

2.3 DATA REDUCTION AND ANALYSIS

Load acceleration forces, extraction forces, and load displacement/time data were obtained for selected drops. Precision space position photographic coverage, high framing rate photographic coverage, and/or on-board photographic coverage was obtained for selected drops. Aircraft operational data and meteorological data were obtained on all drops.

Precision space position photographic data was reduced to obtain rates of load rotation (pitching) during descent and impact, parachute orientation during extraction and descent, vertical and horizontal impact velocities, and basic space position/time information. Telemetered data was reduced to obtain load acceleration peaks and durations, extraction velocity at tip-off, and extraction force profile.

The reduced data was analyzed to determine which load conditions at impact resulted in the lowest acceleration forces on the load. A significant drop height is required in which to achieve the desired load orientation at impact. Too high a drop height will result in a high vertical velocity. The required range of drop heights is obtained by properly balancing these two parameters. To obtain the optimum load orientation envelope in the least drop height, the longitudinal center of gravity location and favorably located attachment point of the extraction line were determined through data interpretation. Extraction velocity data at tip-off was used for determination of limits required to retain a controllable load orientation.

2.4 RESULTS

General test results for each air drop test, and detailed engineering data accrued, are contained in Appendix I.

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | LOLEX System

LOLEX Drop No. 1 Date 6 April 1964

Air Testing Branch Drop No. 322

PURPOSE: To coordinate aircraft, instrumentation, photo coverage and drop zone operations.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP - HEADING (degrees) 300

Man. Press. at IP (in.) - RAMP Level

LOAD:

Weight (lb) 1260 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Distributed rigid load; CG centered on platform 16 inches high; extraction point 21 inches high on load.

CHUTE: 15-foot ringslot, unreefed

DROP ZONE: Hard, flat, dry, gravel

REMARKS: Load was retained on platform after impact. Components and platform undamaged.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 2 | **Date** 7 April 1964

Air Testing Branch Drop No. 323

PURPOSE: To obtain extraction and impact data for load and conditions indicated.

AIRCRAFT OPERATION:

IAS at IP (kt)	82	**FLAPS (degrees)**	15
RPM at IP	2700	**HEADING (degrees)**	300
Man. Press. at IP (in.)	25	**RAMP**	Level

LOAD:

Weight (lb)	2290	**Length (in.)**	90
Width (in.)	62	**Height (in.)**	27

Platform, Wood CEP:

Length (in.)	96	**Width (in.)**	70

Characteristics: Semi-concentrated rigid load; CG centered on platform 18 inches high; extraction point 21 inches high on load.

CHUTE: 15-foot ringslot, unreefed

DROP ZONE: Hard, flat, dry, gravel

REMARKS: Load was retained on platform; load assembly rotated to 20 degrees nose-down attitude after impact before stabilizing into horizontal slide attitude.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 3 Date 7 April 1964

Air Testing Branch Drop No. 330

PURPOSE: To confirm data from previous drop.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2600 HEADING (degrees) 300

Man. Press. at IP (in.) 26 RAMP Level

LOAD:

Weight (lb) 2290 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drop No. 2

CHUTE: Same as Drop No. 2

DROP ZONE: Same as Drop No. 2

REMARKS: Load was retained on platform; load assembly rotated to 5 degrees nose-down attitude after impact before stabilizing into horizontal slide attitude.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 4 Date 8 April 1964

Air Testing Branch Drop No. 324

PURPOSE: To obtain data for load and conditions indicated.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 23 RAMP Level

LOAD:

Weight (lb) 1270 Length (in.) 90

Width (in.) 52 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Distributed rigid load; CG centered on platform 16 inches high; extraction point 21 inches high on load.

CHUTE: 15-foot ringslot, unreefed

DROP ZONE: Hard, flat, dry, gravel

REMARKS: Load was retained on platform after impact.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 5 Date 8 April 1964

Air Testing Branch Drop No. 325

PURPOSE: To confirm data from previous drop.

AIRCRAFT OPERATION:

IAS at IP (kt) 82 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 22 RAMP Level

LOAD:

Weight (lb) 1270 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drop No. 4

CHUTE: Same as Drop No. 4

DROP ZONE: Same as Drop No. 4

REMARKS: Load was retained on platform after impact.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 6 | Date 9 April 1964

Air Testing Branch Drop No. 326

PURPOSE: To determine behavior of load for conditions indicated.

AIRCRAFT OPERATION:

IAS at IP (kt) 84 | FLAPS (degrees) 15

RPM at IP 2550 | HEADING (degrees) -

Man. Press. at IP (in.) 25 | RAMP Level

LOAD:

Weight (lb) 3790 | Length (in.) 90

Width (in.) 62 | Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 | Width (in.) 70

Characteristics: Distributed rigid load; CG centered on platform 19 inches high; extraction point 21 inches high on load and approximated 3 feet from the load.

CHUTE: 22-foot ringslot

DROP ZONE: Loose sandy soil, undulating terrain

REMARKS: Drop conducted in 10-knot crosswind.
Chute pulled to one side during extraction; load extracted straight until tip-off, then reoriented and impacted on one corner. Load broke away from platform, cartwheeled during unstabilized deceleration, after load assembly struck low furrow of ground.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 7 Date 10 April 1964

Air Testing Branch Drop No. 327

PURPOSE: To determine behavior of load for load and conditions indicated and compare with previous drop.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2400 HEADING (degrees) 300

Man. Press. at IP (in.) 23 RAMP Level

LOAD:

Weight (lb) 3790 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Distributed rigid load; CG centered on platform 19 inches high; extraction point 21 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, dry, gravel

REMARKS: Load was retained on platform after impact.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 8 Date 13 April 1964

Air Testing Branch Drop No. 336

PURPOSE: To obtain data for load and conditions indicated.

AIRCRAFT OPERATION:

IAS at IP (kt) 86 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 24 RAMP Level

LOAD:

Weight (lb) 3790 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Distributed rigid load; CG centered on platform 19 inches high; extraction point 21 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, dry, gravel

REMARKS: Load broke away from platform at impact. Air turbulence and wind gusts caused unstable flight path.

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 9 Date 13 April 1964

Air Testing Branch Drop No. 337

PURPOSE: To confirm data from previous drop.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 22 RAMP Level

LOAD:

Weight (lb) 3790 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drop No. 8

CHUTE: Same as Drop No. 8

DROP ZONE: Same as Drop No. 8

REMARKS: Load broke away from platform at impact. Air tubulence and wind gusts caused unstabled flight path. The aircraft was slightly nose-up during load extraction.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data — **LOLEX System**

LOLEX Drop No. 10 — **Date** 14 April 1964

Air Testing Branch Drop No. 338

PURPOSE: To test behavior of load with very high CG and high silhouette; also to check height of extraction clearance.

AIRCRAFT OPERATION:

IAS at IP (kt)	83	FLAPS (degrees)	15
RPM at IP	2450	HEADING (degrees)	300
Man. Press. at IP (in.)	22.5	RAMP	Level

LOAD:

Weight (lb)	2290	Length (in.)	90
Width (in.)	62	Height (in.)	60

Platform, Wood CEP:

Length (in.)	96	Width (in.)	70

Characteristics: **Semi-concentrated rigid load; CG centered on platform 33 inches high; extraction point 36 inches high on load.**

CHUTE: 22-foot ringslot

DROP ZONE: **Hard, flat, damp gravel**

REMARKS: **The load having a silhouette of 60 inches did not strike aircraft during extraction. Load broke away from platform on impact.**

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 11 Date 14 April 1964

Air Testing Branch Drop No. 339

PURPOSE: To test behavior of load with large longitudinal moment of inertia.

AIRCRAFT OPERATION:

IAS at IP (kt) 82 FLAPS (degrees) 15

RPM at IP 2400 HEADING (degrees) 300

Man. Press. at IP (in.) 22 RAMP Level

LOAD:

Weight (lb) 2290 Length (in.) 90

Width (in.) 62 Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Rigid load with mass concentrated at both ends; CG centered on platform 18 inches high; extraction point 21 inches on load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: Load assembly rotated to an acute nose-down attitude after initial impact, but load did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 12 | Date 15 April 1964

Air Testing Branch Drop No. 340

PURPOSE: To test the effects of the aircraft ramp depressed 15 degrees.

AIRCRAFT OPERATION:

IAS at IP (kt) 82 | FLAPS (degrees) 15

RPM at IP 2500 | HEADING (degrees) 300

Man. Press. at IP (in.) 23 | RAMP Depressed 15 degrees

LOAD:

Weight (lb) 2280 | Length (in.) 90

Width (in.) 62 | Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 | Width (in.) 70

Characteristics: Semi-concentrated rigid load; CG centered on platform 18 inches high; extraction point 21 inches high on load.

CHUTE: 15-foot ringslot, unreefed

DROP ZONE: Hard, flat, damp gravel

REMARKS: Part of platform touched the upper roller of the ramp conveyor, and came very close to touching remainder of ramp conveyor. After initial impact, load assembly rotated to a nose-down attitude, but the load did not break away from the platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data — LOLEX System

LOLEX Drop No. 13 — Date 15 April 1964

Air Testing Branch Drop No. 341

PURPOSE: To obtain data for load and conditions indicated and to compare data with previous drop.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 — FLAPS (degrees) 15

RPM at IP 2500 — HEADING (degrees) 300

Man. Press. at IP (in.) 24 — RAMP Depressed 15 degrees

LOAD:

Weight (lb) 2290 — Length (in.) 90

Width (in.) 62 — Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 — Width (in.) 70

Characteristics: Same as Drop No. 12

CHUTE: 22-foot ringslot

DROP ZONE: Same as Drop No. 12

REMARKS: Platform did not touch lower portion of ramp conveyor. Load broke away partially from platform at impact.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data — LOLEX System

LOLEX Drop No. 14 — Date 16 April 1964

Air Testing Branch Drop No. 343

PURPOSE: To test and determine behavior of service load; M38A1 1/4-ton truck on breakaway platform.

AIRCRAFT OPERATION:

IAS at IP (kt) N/A — FLAPS (degrees) N/A

RPM at IP N/A — HEADING (degrees) N/A

Man. Press. at IP (in.) N/A — RAMP N/A

LOAD:

Weight (lb) 3000 — Length (in.) 100

Width (in.) 65 — Height (in.) 60

Platform, Wood CEP:

Length (in.) 120 — Width (in.) 70

Characteristics: CG centered slightly aft of center of platform 35 inches high; extraction point, trailer hook of truck.

CHUTE: 22-foot ringslot

DROP ZONE: N/A

REMARKS: The extraction chute hung on the aircraft ramp and jarred loose after climb-out, approximately 500 feet. The load extracted normally and was totally damaged on impact. The pendulum system and final restraints were modified as a result of this malfunction.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 15 | Date 20 April 1964

Air Testing Branch Drop No. 355

PURPOSE: To test the behavior of the load with the CG aft of center.

AIRCRAFT OPERATION:

IAS at IP (kt) 86 | FLAPS (degrees) 15

RPM at IP 2450 | HEADING (degrees) 300

Man. Press. at IP (in.) 23 | RAMP Level

LOAD:

Weight (lb) 2280 | Length (in.) 90

Width (in.) 62 | Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 | Width (in.) 70

Characteristics: Semi-concentrated rigid load, CG 12 inches (13%) aft of center on platform 18 inches high; extraction point 21 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: Load assembly rotated to 20 degrees nose-down attitude after initial impact; load did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | LOLEX System

LOLEX Drop No. 16 | Date 20 April 1964

Air Testing Branch Drop No. 328

PURPOSE: To obtain data for load and conditions indicated and compare with other drops, also verify findings of previous drop and check extraction clearance.

AIRCRAFT OPERATION:

IAS at IP (kt) 88 | FLAPS (degrees) 15

RPM at IP 2500 | HEADING (degrees) 300

Man. Press. at IP (in.) 24 | RAMP Level

LOAD:

Weight (lb) 2280 | Length (in.) 90

Width (in.) 62 | Height (in.) 65

Platform, Wood CEP:

Length (in.) 96 | Width (in.) 70

Characteristics: Same as Drop No. 15

CHUTE: Same as Drop No. 15

DROP ZONE: Same as Drop No. 15

REMARKS: The extraction chute delayed opening after release from the pendulum. The final load restraint was cut manually and simultaneously the extraction chute deployed. The load did not break away from the platform and the 65-inch silhouette did not strike the aircraft during extraction.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data — **LOLEX System**

LOLEX Drop No. 17 — Date 21 April 1964

Air Testing Branch Drop No. 356

PURPOSE: To test the behavior of a low density load with a 22-foot ringslot extraction chute.

AIRCRAFT OPERATION:

IAS at IP (kt)	87	FLAPS (degrees)	7
RPM at IP	2450	HEADING (degrees)	NR
Man. Press. at IP (in.)	21	RAMP	Level

LOAD:

Weight (lb)	1250	Length (in.)	90
Width (in.)	62	Height (in.)	27

Platform, Wood CEP:

Length (in.)	96	Width (in.)	70

Characteristics: Distributed rigid load; CG centered on platform 16 inches high; extraction point 21 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Loose sandy soil, slight furrows in direction of flight.

REMARKS: Load assembly rotated to a 40-degree nose-down attitude after impact; load did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 18 Date 21 April 1964

Air Testing Branch Drop No. 329

PURPOSE: To determine load behavior for load and conditions indicated; also check high silhouette during extraction.

AIRCRAFT OPERATION:

IAS at IP (kt) 76 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) NR

Man. Press. at IP (in.) 22 RAMP Level

LOAD:

Weight (lb) 1250 Length (in.) 90

Width (in.) 62 Height (in.) 66

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drop No. 17 but with 66-inch high silhouette.

CHUTE: 22-foot ringslot

DROP ZONE: Same as Drop No. 17

REMARKS: No kite action was observed during extraction. The load having a silhouette of 66 inches did not strike aircraft during extraction. Load assembly rotated to 30 degrees nose-down attitude after impact; load did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 19 Date 22 April 1964

Air Testing Branch Drop No. 357

PURPOSE: To test and determine behavior of service load, M38A1 1/4-ton truck, on breakaway platform.

AIRCRAFT OPERATION:

IAS at IP (kt) 81 FLAPS (degrees) 15

RPM at IP 2450 HEADING (degrees) 300

Man. Press. at IP (in.) 22.5 RAMP Level

LOAD:

Weight (lb) 3000 Length (in.) 100

Width (in.) 65 Height (in.) 60

Platform, Wood CEP:

Length (in.) 120 Width (in.) 70

Characteristics: CG centered slightly aft of center of platform 35 inches high; extraction point, trailer hook of truck.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: Of the 284 feet of decelerating distance, the platform skidded 79 feet and the vehicle rolled 204 feet. Maximum wheel bounce of the vehicle was approximately 30 inches high after impact. There was no apparent damage to the vehicle, which was driven away.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 20 Date 22 April 1964

Air Testing Branch Drop No. 352

PURPOSE: To obtain data for load conditions indicated and compare with Drops No. 4 and 5; also check 66-inch clearance during extraction.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 24 RAMP Level

LOAD:

Weight (lb) 1250 Length (in.) 90

Width (in.) 62 Height (in.) 66

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drops No. 4 and 5, but with 66-inch high silhouette.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: The load having a silhouette of 66 inches struck aircraft during extraction; there was approximately 6 inches vertical interference. The load assembly rotated to 20 degrees nose-down attitude after impact, before stabilizing to a horizontal slide attitude; the load did not break away from the platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 21 Date 23 April 1964

Air Testing Branch Drop No. 358

PURPOSE: To test behavior of load with moderately high CG.

AIRCRAFT OPERATION:

IAS at IP (kt) 80 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 23 RAMP Level

LOAD:

Weight (lb) 2250 Length (in.) 90

Width (in.) 62 Height (in.) 33

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Semi-concentrated rigid load, CG centered on platform 24 inches high; extraction point 27 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: Load assembly rotated to 5 degrees nose-down attitude after impact, before stabilizing at a horizontal slide attitude; load did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 22 Date 24 April 1964

Air Testing Branch Drop No. 359

PURPOSE: To verify test No. 19.

AIRCRAFT OPERATION:

IAS at IP (kt) 79 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 24.5 RAMP Level

LOAD:

Weight (lb) 3000 Length (in.) 100

Width (in.) 65 Height (in.) 60

Platform, Wood CEP:

Length (in.) 120 Width (in.) 70

Characteristics: Same as Drop No. 19

CHUTE: Same as Drop No. 19

DROP ZONE: Same as Drop No. 19

REMARKS: Of the 172 feet of decelerating distance, the platform skidded 22 feet and the vehicle rolled 150 feet. Results were similar to those of Drop No. 19.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data LOLEX System

LOLEX Drop No. 23 Date 24 April 1964

Air Testing Branch Drop No. 354

PURPOSE: To obtain data for load and conditions indicated and to verify results of Drop No. 21.

AIRCRAFT OPERATION:

IAS at IP (kt) 74 FLAPS (degrees) 15

RPM at IP 2500 HEADING (degrees) 300

Man. Press. at IP (in.) 23.5 RAMP Level

LOAD:

Weight (lb) 2250 Length (in.) 90

Width (in.) 62 Height (in.) 33

Platform, Wood CEP:

Length (in.) 96 Width (in.) 70

Characteristics: Same as Drop No. 21

CHUTE: Same as Drop No. 21

DROP ZONE: Same as Drop No. 21

REMARKS: Load assembly rotated to 15-degree nose-down attitude after impact before stabilizing at horizontal slide attitude. Load partially broke away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | LOLEX System

LOLEX Drop No. 24 | Date 27 April 1964

Air Testing Branch Drop No. 345

PURPOSE: To test behavior of load impacting in rough terrain.

AIRCRAFT OPERATION:

IAS at IP (kt) 81 | FLAPS (degrees) 15

RPM at IP 2500 | HEADING (degrees) 280

Man. Press. at IP (in.) 26 | RAMP Level

LOAD:

Weight (lb) 2250 | Length (in.) 90

Width (in.) 62 | Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 | Width (in.) 70

Characteristics: Semi-concentrated rigid load, CG centered on platform 18 inches high; extraction point 21 inches high on load.

CHUTE: 22-foot ringslot

DROP ZONE: Rough, sandy terrain with some scrub vegetation.

REMARKS: The load skidded one foot, dug in and separated from the platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data **LOLEX System**

LOLEX Drop No. 25 Date 28 April 1964

Air Testing Branch Drop No. 346

PURPOSE: To test behavior of load on 144-inch platform at 33 pounds per square foot; also to check 66-inch high clearance during extraction.

AIRCRAFT OPERATION:

IAS at IP (kt) 82 FLAPS (degrees) 15

RPM at IP 2450 HEADING (degrees) 300

Man. Press. at IP (in.) 24 RAMP Level

LOAD:

Weight (lb) 2400 Length (in.) 90

Width (in.) 62 Height (in.) 66

Platform, Wood CEP:

Length (in.) 144 Width (in.) 70

Characteristics: Semi-concentrated rigid load, CG centered on platform 18 inches high; extraction point 21 inches high and 2-foot from end of load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: The load having a silhouette of 66 inches struck ceiling of aircraft at wing root. Transient stick forces noticed by pilot during extraction. Load remained on platform after impact.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data — LOLEX System

LOLEX Drop No. 26 — Date 28 April 1964

Air Testing Branch Drop No. 361

PURPOSE: To test load behavior when dropped high and with aircraft in nose-up attitude.

AIRCRAFT OPERATION:

IAS at IP (kt) 77 — FLAPS (degrees) 15

RPM at IP 2450 — HEADING (degrees) 300

Man. Press. at IP (in.) 23 — RAMP Level

LOAD:

Weight (lb) 2250 — Length (in.) 90

Width (in.) 62 — Height (in.) 27

Platform, Wood CEP:

Length (in.) 96 — Width (in.) 70

Characteristics: Same as Drop No. 24

CHUTE: Same as Drop No. 24

DROP ZONE: Hard, flat, damp gravel

REMARKS: The load bounced at impact but no nose-down rotation occurred. The load remained on the platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

YUMA PROVING GROUND
YUMA, ARIZONA

Test Data | **LOLEX System**

LOLEX Drop No. 27 | Date 29 April 1964

Air Testing Branch Drop No. 362

PURPOSE: To test behavior of load on 180- by 70-inch platform at 33 pounds per square foot and to check 66-inch clearance during extraction.

AIRCRAFT OPERATION:

IAS at IP (kt) 88 | FLAPS (degrees) 7

RPM at IP 2600 | HEADING (degrees) 300

Man. Press. at IP (in.) 26.5 | RAMP Level

LOAD:

Weight (lb) 3200 | Length (in.) 90

Width (in.) 62 | Height (in.) 66

Platform, Wood CEP:

Length (in.) 180 | Width (in.) 70

Characteristics: Semi-concentrated rigid load CG near center of platform, 18 inches high; extraction point 21 inches high and 3.5 feet from end of load.

CHUTE: 22-foot ringslot

DROP ZONE: Hard, flat, damp gravel

REMARKS: High transient stick forces noticed by pilot during extraction. The load rotated only to horizontal attitude after impact and did not break away from platform.

STEYP-TAT Form 17, 9 Jul 64 (OT)

KEY TO ENGINEERING DATA

D_1 - Distance on ground from point of parachute release to point where parachute bag first struck the ground.

D_2 - Distance from point where parachute bag first struck the ground to point where load first touched the ground.

D_3 - Decelerating distance of load on ground.

D_4 - Sum of D_1, D_2 and D_3.

T_2 - Time interval from start of movement of load in aircraft to tip-off.

T_3 - Time interval from tip-off to initial contact of load with ground.

T Total - Time interval from time of parachute release to time of end of deceleration of load on ground.

Height of Tip-Off - Gear down clearance of aircraft when center of load passes the end of the aircraft ramp. Add 4-1/2 feet for actual height of cargo floor above ground surface.

Average Acceleration - Average acceleration of load during extraction from instant of start of load movement in aircraft to tip-off, in g.

g-Forces - Maximum g-forces at impact recorded at each end of test frame. The aft end of the load is considered to be the end with the extraction line attachment point.

A_1 - Maximum angular deviation of extraction line from horizontal, during descent of load, i.e., 6 degrees up.

A_2 - Maximum pitch-up angle of load during descent, i.e., 18 degrees nose-up.

A_3 - Maximum pitch-down angle of load during descent, i.e., 5 degrees nose-up.

A_4 - Pitch attitude of load at impact, i.e., 8 degrees nose-up.

R_1 - Rate of change of pitch attitude of load just before impact, i.e., 10 degrees per second down.

V_v - Vertical velocity just before impact, 18 feet per second.

V_h - Horizontal velocity just before impact, i.e., 67 feet per second.

[illegible] DATA

Drop No.	Date	Max Ext Force (lb)	Ext Vel Tip-Off (ft/sec)	Ht at Tip-Off (ft)	g-Forces Vert Fwd/Aft	Long. Fwd/Aft	Lat Fwd/Aft	Avg Accel (g)	A_1 (deg)	A_2 (deg)	A_3 (deg)	A_4 (deg)	R_1 (°/sec)	V_v (ft/sec)	V_h (ft/sec)	D_1 (ft)	D_2 (ft)	D_3 (ft)	D_4 (ft)	T_2 (sec)	T_3 (sec)	T Total (sec)
1	6 Apr 64			4.5												301	363	135	799			
2	7 Apr 64	4800	26	6	120/106	26/34	23/18	0.70	5 down	14 nose up	6 nose up	6 nose up	18 down	20	83	280	443	100	823	1.17	0.78	7
3	7 Apr 64	4900	40	2.5	97/77	24/33	19/20	0.86	3 down	7 nose up	3 nose up	3 nose up	20 down	18	70	148	486	100	734	1.45	0.81	6
4	8 Apr 64	1900	38	3	130/61	38/37	30/23	0.80								129		104		1.25	0.85	6.5
5	8 Apr 64	2300	36	3	121/154	44/35	33/18	1.07		20 nose up		20 nose up	30 up	Approx 15	Approx 90	139	591	99	889	1.04	0.67	6.5
6	9 Apr 64			3														50	690			6
7	10 Apr 64			1												229	448	123	810			6.5
8	13 Apr 64	6250	33	6	163/177	142/149	46/38	0.72		10 nose up	8 nose up	10 nose up	Approx 0	16	Approx 80	300	335	62	697	1.42	0.89	7
9	13 Apr 64			4					9 up	11 nose up	None	Approx 10 nose up	Approx 0	21	82	218	495	86	799			7
10	14 Apr 64			4												206	460	68	740			6
11	14 Apr 64	4200	38.5	2.5				0.84								219	521	129	869	1.42		7
12	15 Apr 64			6						9 nose up	5 nose up	5 nose up	10 down	21	98	185	529	195	909			8
13	15 Apr 64		20					0.46								159	514	77	730	1.33		7
15	20 Apr 64			3												200	488	92	780			6.5
16	20 Apr 64	4700		3	98/66	52/39 Max 120										311	1617	142	2070	0.95	0.70	
17	21 Apr 64			4.5														32	622			6
18	21 Apr 64			3.5														37	627			7
19	22 Apr 64			2												208	473	284	965			7
20	22 Apr 64	4090	49	2.5	99/48	37/23	22/17	1.01	5 down	12 nose up	9 nose up	11 nose up	Very slight	17	78	153	509	94	756	1.38	0.70	6.5
21	23 Apr 64			7												170	409	68	647			
22	24 Apr 64			3.5												323	487	172	982			11
23	24 Apr 64	4800	40	7	140/---		46/28	1.13								128	469	50	647	1.10	1.52	6.5
24	27 Apr 64			8														56				
25	28 Apr 64			3												126	494	156	776			
26	28 Apr 64			Approx 9																		
27	29 Apr 64			Approx 3.5														Approx 190				

NOTE: Drop No. 14, 16 Apr 64, malfunctioned.

METEOROLOGICAL DATA

Drop No.	Date	Air Temp (C°)	Relative Humidity (%)	Soil Temp (C°)	Pressure (mbs)	Density Altitude (m)	Absolute Air Dens (kg/m^3)	Surface Winds Direction	Surface Winds Speed (mps)
2	7 Apr 64	24.4	13	33.9	1005.3	434	1.1751	360	7.8
3	7 Apr 64	26.4	15	37.8	1004.4	518	1.1651	360	4.6
4	8 Apr 64	26.2	34	33.9	1006.1	512	1.1680	358	3.4
5	8 Apr 64	26.9	31	38.8	1005.6	536	1.1650	319	1.5
8	13 Apr 64	30.6	13	39.5	1003.9	762	1.1487	335	8.3
9	13 Apr 64	33.6	9	43.9	1003.1	759	1.1387	006	2.0
10	14 Apr 64	31.4	7	40.6	1004.0	701	1.1446	113	0.5
11	14 Apr 64	34.1	10	45.6	1004.0	793	1.1360	340	2.0
12	15 Apr 64	30.7	10	42.2	998.4	729	1.1424	330	2.1
13	15 Apr 64	34.9	8	48.0	998.2	866	1.1260	Calm	Calm
14	16 Apr 64	30.9	11	40.7	995.6	741	1.1402	176	2.5
15	20 Apr 64	17.8	38	32.2	1005.3	220	1.2080	300	0.5
16	20 Apr 64	20.2	32	39.3	1005.3	310	1.1940	006	1.6
19	22 Apr 64	24.3	26	38.9	987.3	631	1.1533	220	3.1
20	22 Apr 64	29.7	19	45.0	997.0	710	1.1439	200	3.1
23	24 Apr 64	18.2	32	31.1	1001.2	302	1.1942	265	6.2
24	27 Apr 64	25.1	21	35.0	998.5	546	1.1630	162	3.1
25	28 Apr 64	26.5	16	36.7	994.3	625	1.1535	086	3.1
27	29 Apr 64	23.0	35	36.7	996.8	503	1.1680	239	2.1

APPENDIX II

FINDINGS

1. Drop Zone Length

The time required for the opened canopy to extract the load 18.7 feet from aircraft station 355 to tip-off, and for the load to descend and contact the ground, is typically 2 to 2-1/2 seconds. In this period of time, at 80 knots ground speed, the aircraft will travel about 350 feet. The load, on impact, is generally only about 10 feet behind the tail of the aircraft, so that the distance covered by the load up to this time is only slightly less than that covered by the aircraft. Depending on the type of load and on drop zone conditions, an additional 30 to 300 feet is required to decelerate the load after impact. The minimum horizontal drop zone length is therefore on the order of 400 to 650 feet. Since the distance required for deceleration is variable and not readily predictable, the larger figure is more realistic.

2. Drop Height

In the standard air delivery system with recovery parachute, the vertical velocity at impact is equal to that from a free-fall of 10 to 15 feet. In LOLEX operations, since the parachute does not pull with any significant vertical force component, little vertical retardation is furnished by the parachute, and the drop height should therefore not exceed 10 to 15 feet if LOLEX is to provide the same low vertical velocity as is provided by recovery parachutes. (The aerodynamic forces on the LOLEX platform do not offer any substantial aid in inhibiting vertical velocity build-up, because of the combination of low air speed and low aspect ratio of the platform surface, and because of the relatively high loading.) As soon as any significant horizontal velocity component at impact is introduced, whether 50 knots or 100, load dynamics becomes a problem area, and the drop height becomes an increasingly significant factor in load survivability. Concurrent with the introduction of horizontal velocity, unpredictable load shift occurs at impact, due to high transient horizontal frictional forces, which in turn result directly from the high transient normal forces induced by the vertical velocity component. This unpredictable load shift results in a grossly unpredictable degree of effectiveness of the honeycomb, which may fail quickly in shear, and bottom out, or else remain totally rigid and uncrushed. As a result characteristically, transient g forces of up to 200 g's vertically and 150 g's horizontally were transmitted to the load when touchdown occurred on a hard flat earth surface.

Alternatives to the problem are: (1) reduce the drop height, (2) decrease the load shift or establish a predictable load shift, and (3) incorporate the use of protective packaging. Reducing the drop height is the simplest expedient, if permissible under aircraft operational requirements. Reducing the drop height would also permit the load to touch down before any forward rotation of the load had progressed to such an extent that the load would be in a nose-down attitude conducive to digging-in. Best predictable load survivability occurs with a moderate nose-up attitude of the platform at impact, with no rotation, so that no digging-in occurs, and yet only minimal rebound or pitching occurs. (Rebound and pitching should be kept low so as to prevent subsequent digging-in or shock to the load before the load stabilizes into a skid). An alternative to the nose-up load attitude would be to develop a new and more expensive platform and rigging method which would provide controlled impact dynamics and which would permit consistent effectiveness of the honeycomb. At present, best load survivability, based on the data obtained from these tests, is achieved with a drop height of 3 to 6 feet of gear-down clearance.

3. Aircraft Attitude and Flight Path

a. Load behavior is less predictable when the aircraft is in a nose-up attitude, or in a transient condition, during tip-off. Under such conditions load survivability becomes more of a hit-or-miss proposition, partly because of instability imparted to the load, and partly because of increased and unpredictable aerodynamic forces imparted to the load. Load behavior is more consistent when the aircraft attitude is straight and level, with the cargo floor horizontal, and with a minimum of transient power changes, attitude changes, and flight path changes, asymmetrical thrust, and sideslip during extraction and tip-off. However, as an expedient, if it is necessary to drop a load from a higher height than is optimum for load survivability, and if the mechanical load moment about the attachment point is relatively large, load survivability will be aided if the aircraft attitude is nose-up at tip-off. The reason for this seeming paradox is that the initial nose-up attitude imparted to the load tends to conteract the effect of excessive forward rotation incurred during the extended drop. This expedient was suggested by the results of ATB test No. 358, and was verified by the results of ATB test No. 361.

b. When a load must be dropped in a crosswind, the parachute will pull generally straight back, nearly in line with the aircraft, as long as the aircraft is crabbed with symmetric thrust, rather than sideslipped. If the parachute does pull slightly to the side, however, the load will track true on the conveyors until tip-off, and no significant side-swipe to the aircraft occurs.

c. When the alternative presents itself either to fly directly into the wind or to follow a drop zone furrow or terrain contour, load survivability is increased if the terrain contour is followed exactly.

4. Horizontal Speed

If the drop zone is a hard, flat, dry, earth surface, and unlimited in length, observations show that differences in the horizontal velocity component of the load at impact are relatively unimportant for load survivability. For realistic conditions, however, wherein the drop zone surface may be undulating and/or easily penetrated (such as loose earth or mud), the amount of the horizontal velocity component of the load at impact directly affects the load dynamics and the resulting forces exerted on the load. Therefore, unless the condition of each drop zone is known, the horizontal velocity at impact should be kept to a minimum. Achievement of this low speed could be aided by: (1) low aircraft IAS, (2) up-wind flight path, (3) large parachute, (4) light load, or (5) high drop height. Of these possibilities, the aircraft IAS cannot be compromised below fixed values, which should not be exceeded whenever feasible; the up-wind flight-path cannot be relied upon, the load weight capability of the LOLEX system should not be compromised (though two small loads are more likely to survive, at least in part, than one large load); and only the parachute size and drop height remain valid and negotiable. Therefore, the larger (22-foot) parachute should be considered standard for all loads of 1000 to 4000 pounds, with a 15-foot parachute used only as an option for loads under 2000 pounds, if over 50 inches in height, at aircraft speeds of 85 knots or more. As for the drop height, this now becomes a compromise between the factors involved in vertical impact velocity (which indicates a low drop height, as previously discussed), versus the factors involved in horizontal impact velocity (which suggests a high drop height). At best, the best drop height for load survivability can only be approximated, both in theory and in practice. Since the drop height more directly affects the vertical impact velocity, vertical velocity considerations should be the primary basis used in establishing optimum drop height

values, rather than horizontal velocity considerations. Consequently, increasing the drop height is not a valid expedient for lessening the horizontal impact velocity, unless the drop zone is extremely rough.

5. Load and Rigging

a. Aerodynamic effects on the load during descent were not measured or quantitatively analyzed, since they play a relatively minor role in load behavior, and since each individual service load will have its own distinct reaction to aerodynamic forces. However, aerodynamic effects do exist and can create unpredictable results as to load attitude at impact if platforms are not kept to moderate sizes. As for the attachment point of the extraction line, test results showed that if located slightly above the load CG, the line tended to aid in keeping the load in a slightly nose-up attitude. Being attached to the load rather than the platform the line tended to minimize load shift or separation during impact, and this procedure should be used in service.

b. Lateral load CG should be centered on the platform. If well centered, the load retains good lateral stability. If off-center, the load will become progressively unstable with increasing drop height.

c. Platforms longer than "standard" 96 by 70 inches were found to be difficult to load, more likely to scrub the aircraft buffer boards on extraction, and more likely to cause high transient stick forces in the aircraft control system during tip-off. They would also tend to cause unpredictable aerodynamic effects during extraction and descent.

d. Load silhouettes of more than 60 inches were found to be unreliable as to clearance during extraction, particularly under unstable aircraft conditions and with light loads.

e. Variations in load moments of inertia were found to be of little significance. However, to minimize reaction to any destabilizing forces on the one hand, and to minimize transient stick forces and ramp stresses on the other, the load should be uniformly distributed if practical. To minimize aft-end instability at impact, any unavoidable weight concentrations should be located towards the center rather than at the ends.

f. It was determined in the latter stages of the tests that a load CG located slightly aft of the center of the platform (towards the extraction line attachment point) tended to reduce forward rotation of the load during descent. At the same time, the relative positions of the CG and the extraction line attachment point prevented too severe a backward rotation at tip-off, provided the extraction velocity was sufficiently high. Accordingly, the load CG should be slightly aft for best load survivability, since this location gives the best pitch attitude at impact, with minimum forward rotation just prior to touchdown.

APPENDIX III

PHOTOGRAPHS

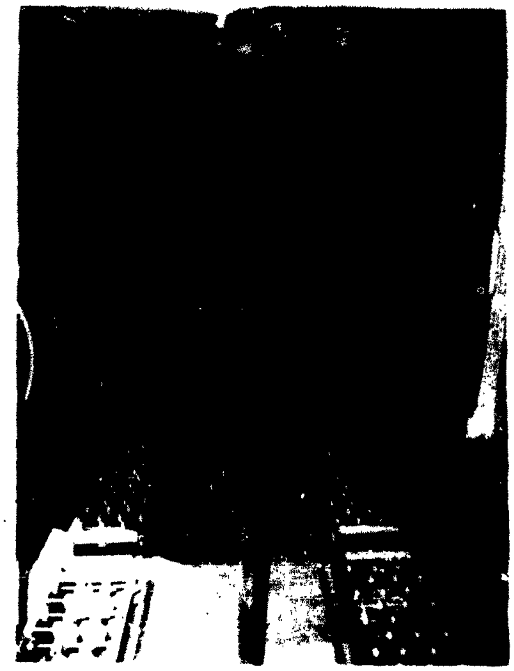


Figure 1: Load of 2250 pounds, 96- by 70-inch platform, 15-foot ringslot unreefed extraction parachute, located at Station No 355.

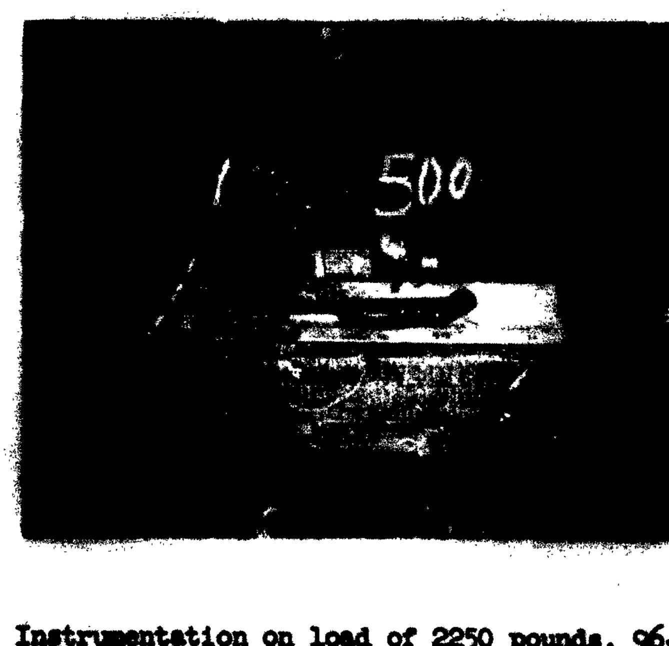


Figure 2: Instrumentation on load of 2250 pounds, 96- by 70-inch platform, located at Station No. 355.

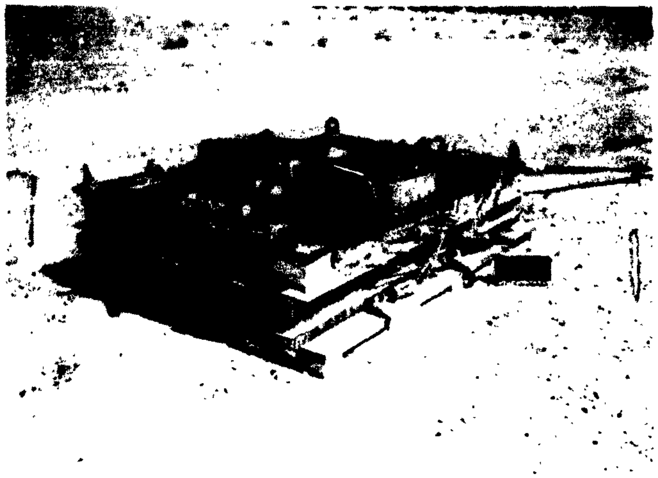


Figure 3: Load of 2250 pounds, 96- by 70-inch platform, 15-foot ringslot unreefed extraction parachute after impact upon a hard, flat, gravel drop zone.

Figure 4: Load of 2250 pounds, for evaluation of maximum silhouette height for safe cargo compartment clearance.

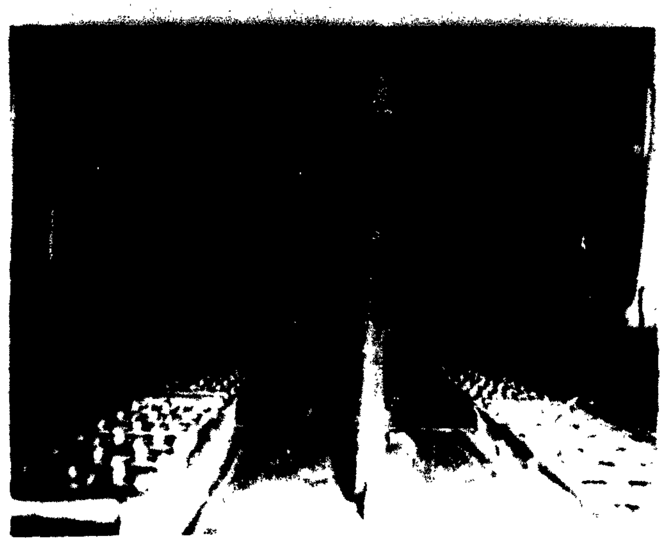


Figure 5: Load composed of an M38A1 1/4-ton truck, 120- by 70-inch breakaway platform, 22-foot ringslot extraction parachute.

Figure 6: An M38A1 truck after air drop upon a hard, flat, damp, gravel drop zone.

APPENDIX IV

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APPENDIX XI -

AIRCRAFT CONTROL, FLIGHT SAFETY, AND CREW PROCEDURE EVALUATION,

U. S. ARMY AVIATION TEST BOARD

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

STEBG-ACFT 10 July 1964

SUBJECT: Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft, USATECOM Project Number 4-4-7475

TO: President
U. S. Army Airborne, Electronics and Special Warfare Board
ATTN: STEBF-AB
Fort Bragg, North Carolina 28307

1. References:

a. Letter AMSTE-BG, U. S. Army Test and Evaluation Command, 29 November 1963, subject: "Directive for Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft, USATECOM Project Number 4-4-7475."

b. Coordinated Plan of Test, USATECOM Project Number 4-4-7475, "Integrated Engineering/Service Test of Low Level Extraction System (LOLEX) from CV-2B Aircraft."

2. The aircraft control, flight safety, and crew procedures portions of the Integrated Engineering/Service Test of the Low Level Extraction System (LOLEX) were evaluated by personnel of this Board during the period 30 March 1964 through 25 June 1964. Details and results of this evaluation are forwarded for your information and retention. Results and analysis contained in Inclosure No. 1 are premised on criteria established by other participating agencies (U. S.

STEBG-ACFT 10 July 1964

SUBJECT: Integrated Engineering/Service Test of Low Level Extraction Techniques (LOLEX) from CV-2B Aircraft, USATECOM Project Number 4-4-7475

Army Aviation Test Activity, Yuma Proving Ground, and U. S. Army Airborne, Electronics and Special Warfare Board) and therefore have no validity unless considered in accordance with these criteria.

1 Incl
Details and Results of Evaluation

A. J. RANKIN
Colonel, Armor
President

Copies furnished:
Pres, USAAESWBD
CO, Yuma Proving Ground
CO, USAATA
CG, USATECOM, ATTN: AMSTE-BG

DETAILS AND RESULTS OF EVALUATION

1.0. INTRODUCTION.

1.0.1. The aircraft control, flight safety, and crew procedures portions of the Integrated Engineering/Service Test of the Low Level Extraction System (LOLEX) were evaluated by U. S. Army Aviation Test Board (USAAVNTBD) personnel during the period 30 March 1964 through 25 June 1964. The USAAVNTBD evaluation was conducted concurrently with the U. S. Army Aviation Test Activity (USAATA), Yuma Proving Ground (YPG) and U. S. Army Airborne, Electronics and Special Warfare Board (USAAE&SWBD) portions of the test. A combined total of 93 extractions at Yuma Proving Ground, Arizona, and Fort Bragg, North Carolina, were used for data collection and evaluation.

1.0.1.1. Thirteen Army aviators participated in the test. Aviator experience level ranged from three pilots undergoing CV-2 transition training to three pilots each with more than 500 hours of CV-2 pilot time.

1.0.1.2. The questionnaire attached as appendix A was completed by the pilot after each extraction. Data and comment from this questionnaire provided the statistical basis for this report.

1.0.2 All tests conducted by the USAAVNTBD were premised on aircraft and load survivability criteria established by other participating agencies (USAATA-YPG-USAAE&SWBD). Missions were at all times flown within the USAATA - recommended safety-of-flight release (appendix B). Load survivability engineering tests conducted by YPG established the following aircraft flight profile at extraction as being most desirable:

a. Wheel-to-ground clearance - 3 to 6 feet.

b. A flight attitude which places the cargo floor (longitudinal axis of the airplane) parallel to the terrain of the drop zone (DZ).

c. Cargo ramp level.

d. Symmetrical power on engines.

e. Coordinated flight (crosswind correction to allow parallel flight into the relative wind).

Incl 1

f. Airspeed of 80 to 90 knots.

1.1. AIRCRAFT CONTROL EVALUATION.

1.1.1. Objective.

To determine:

a. Controllability of the CV-2B Airplane during all phases of the LOLEX sequence.

b. Aviator ability to fly the airplane in accordance with load survivability and flight safety criteria.

1.1.2. Method.

The airplane was flown and extractions (single, dual, and multiple) were completed at takeoff gross weights from 23,000 to 28,500 pounds. Extractions were completed within both forward and aft center-of-gravity (c.g.) limits using 500-pound graduated increments from 23,000 to 28,500 pounds. A total of 92 loads varying in weight from 900 to 4250 pounds was dropped.

1.1.3. Results.

1.1.3.1. Uncontrollable Airplane Reactions.

As each extracted load moved aft from its resting position until clear of the airplane, momentary pitching about the lateral axis was experienced. The transitory pitching moment was most noticeable when the airplane c.g. at takeoff approached either the forward or aft limit. With a load weight of 2500 pounds or below, the pitch was barely preceptible. As the load weight increased above 2500 pounds, the pitch increased in magnitude. Platforms 8, 12, and 14 feet long were used in this test. As the length of the platform increased, the magnitude of the pitch increased.

Three-thousand nine-hundred and seventy pounds of 5-in-1 rations on a 14-foot platform caused the greatest reaction which was an estimated 3-to-5 degrees of rotation above and below the horizontal.

In the lighter load weight ranges, the transitory pitching was barely preceptible in the control column. In heavier weight

ranges (3000-4000 pounds) very definite control pressure was required to prevent over displacement of the control column.

As each extracted load cleared the ramp the airplane "ballooned." The magnitude of this upward displacement increased as the weight of the load extracted increased. Displacement with a 1000-pound load averaged 1 to 1-1/2 feet. Extraction of a 4000-pound load resulted in a 5- to 7-foot displacement.

1.1.3.2 Pilot Controllable Airplane Conditions.

Wheel-to-Ground Clearance. (Desired clearance is 3 to 6 feet above the terrain.)

The average drop height for the 93 extractions was 6.1 feet with 35 percent in the 3- to 6-foot range. Seventy-two percent of the LOLEX passes had wheel-to-ground clearance of 8 feet or below.

The average of pilot estimates of drop height for 93 extractions was 7.1 feet with 84.9 percent of these estimates being 8 feet or below.

Pilot experience, both in terms of total flight time and CV-2 flight time, was not a significant factor in ability to reach desired extraction altitude. The average height on the first pass over a DZ was 10 feet with a range of 7 to 30 feet.

Vegetation, or lack of it, on the DZ was an important factor in the pilot's ability to estimate drop height. Over large, cleared, sandy areas, the pilot tended to underestimate his actual height by about 30 percent. Over terrain covered by small shrubs, trees, or material objects (vehicles, personnel, etc.), the estimated and actual drop heights were more nearly equal (5 - 10 percent error).

Flight Attitude During Extraction Sequence. (Desired flight attitude places the cargo floor parallel to the DZ.)

Sixty-nine (74.2 percent) of the 93 extractions were completed with the airplane floor parallel to the surface of the DZ. Eighteen (19.3 percent) were made with the airplane nose above the parallel position and 6 (6.5 percent) with the nose below parallel or oscillating about the parallel position.

Symmetrical Power.

The average power used was 22.5 inches of manifold pressure (m.p.) with the propellers at the full increase r.p.m. position. The range for 93 passes varied from a low of 18 inches m.p. to a high of 31 inches m.p. with 68.8 percent in the range of 22 through 24 inches m.p.

Power settings on either end of the range scale resulted from improperly planned approaches, which required large changes of power in order to reach proper height or airspeed for extraction.

Coordinated Flight.

Ninety-two of the LOLEX sequences were flown under conditions of coordinated flight. Wind conditions varied from a maximum of 25 knots headwind to 30 knots at 90 degrees to a 15-knot tail wind component. In all cases, while under the influence of the airplane slip stream, the extraction parachute and line were oriented parallel with the cargo compartment of the airplane.

One extraction was conducted with the airplane in an uncoordinated side slip condition with right wing low and left rudder for alignment. The parachute under this uncoordinated flight condition immediately oriented itself to the airplane slipstream which was not parallel to the cargo compartment.

Airspeed. (Desired range is 80 to 90 knots.)

Average airplane airspeed for the 93 drops was 81 knots. Eighty-three percent of the passes were in the range of 80 through 90 knots; 36 passes were at 80 knots, 16 at 85 knots, and 7 at 90 knots.

1.1.4. Analysis.

1.1.4.1. The uncontrollable airplane reactions, caused by the changes in c.g. as the load moves aft, are not peculiar to LOLEX alone. The same conditions occur in standard aerial delivery from altitude. They do, however, become more apparent in LOLEX operations because of the airplane's close proximity to the ground. The transitory pitching action and vertical displacement are greater mental hazards than actual flight hazards. At no time during this test did either of these reactions endanger the airplane or crew.

1.1.4.2. The results obtained from evaluating the pilot's ability to fly the airplane, during the LOLEX sequence, in accordance with load survivability criteria are considered satisfactory. While pilot experience does not appear to affect ability to meet load survivability criteria, there can be no doubt that training and increased CV-2B proficiency will increase the probability of more consistent performance within these criteria.

1.1.4.3. Specifically, test results indicate that any CV-2B-qualified Army aviator should be capable of operating the airplane in such a manner as to complete the LOLEX sequence successfully. With regard to airplane control, LOLEX may be designated a normal operational capability of the CV-2B.

1.2. SAFETY OF FLIGHT EVALUATION.

1.2.1. Objective.

To determine any unsafe flight conditions resulting from the malfunction of a component of the LOLEX system.

1.2.2. Method.

Malfunctions and situations caused by LOLEX component malfunction were analyzed for cause, effect, and possible corrective action.

1.2.3. Results.

1.2.3.1. Four malfunctions of the LOLEX system components occurred during the conduct of the test. Each malfunction resulted in a failure of the extraction parachute to deploy and extract the load properly. Emergency procedures had to be employed to eject the load from the airplane. (See appendix C for details of malfunction.)

1.2.3.2. Standard aerial delivery procedures for rigging and restraining the load in the airplane proved unacceptable for LOLEX operations. The requirement that the airplane gain altitude rapidly immediately following the LOLEX pass precluded re-restraining the load prior to correcting a malfunction of components located aft of the load. It was therefore determined that, should the extraction parachute fall free of the ejection rack but fail to extract the load, the only emergency procedure available was to complete a gravity extraction.

1.2.3.3. During the initial phases of testing the LOLEX components or procedures listed below caused malfunctions which produced unsafe flight conditions. Prior to completion of testing, modified components or procedures were devised which eliminated the probability of malfunction.

With the cargo ramp in the level position, the pendulum hook installed as standard equipment in the CV-2B was of insufficient length to cause the 22-foot ring slot extraction parachute to clear the airplane without striking the floor. (Pendulum arm was extended approximately 9-1/2 inches.)

The standard aerial delivery rigging procedure which places the load final restraint and the final restraint cutting device on the rear of the load provides no method for manually cutting this restraint without personnel moving to the rear of the load. (Final restraint was moved to the forward end of the load.)

1.2.4. Analysis.

1.2.4.1. The LOLEX component malfunctions encountered during testing resulted in an unsafe flight condition in that:

a. The load could not be manually ejected from the airplane utilizing emergency procedures.

b. The possibility always existed, as it does in standard aerial delivery, that the extraction parachute would fully deploy but the load become lodged in the aircraft. In this configuration, airplane climb capability is non-existent or, at best, marginal (appendix B).

1.2.4.2. Modifications to the LOLEX system components and rigging procedures utilized in the latter stages of testing either eliminated or greatly reduced the possibility of the previously mentioned malfunctions occurring. Platforms, skid-boards, and rigging procedures utilized during the test were of such dimensions and construction as to greatly reduce the probability of the load lodging in the airplane.

1.2.4.3. If the LOLEX system components, rigging procedures, and emergency procedures in use at the conclusion of testing are designated as standard, the LOLEX system will present no unacceptable flight hazards.

1.3. CREW PROCEDURES.

1.3.1. Objective.

To determine pilot/copilot flight procedures and cargo compartment procedures to be utilized during LOLEX operations with special emphasis to be given to suitability for LOLEX of procedures currently published in DA TM 55-1510-206-10 with changes, "Operator's Manual AC-1 Aircraft," June 1962, and TM 10-500-5, "Airdrop of Supplies and Equipment AC-1 and AC-1A (Caribou) Army Aircraft - Preparation, Loading and Load Release Procedures," June 1962.

1.3.2. Method.

1.3.2.1. Preflight and Flight Procedures.

Testing was begun utilizing procedures published in chapters 3 and 4, TM 55-1510-206-10. Special emphasis was given to evaluating paragraph 2-9, section II, chapter 3, "Interior Inspection" paragraphs 3-16 and 3-17, section III, chapter 3, "Before Landing" and paragraphs 3-25 and 3-26, section III, chapter 3, "Go-Around."

1.3.2.2. Airdrop Procedures.

In-flight and air drop procedures published in section VI of TM 10-500-5 were evaluated. Special attention was directed toward adequacy of published time sequences and malfunction procedures.

1.3.3. Results.

1.3.3.1. Preflight Procedures.

Preflight procedures as published in TM 55-1510-206-10 proved to be generally adequate. One sub-paragraph, 2-9.4 ("Cargo - Correctly Loaded and Secured") proved to be too general in that it did not provide sufficient detail to insure thorough inspection.

1.3.3.2. Flight Procedures.

Within the LOLEX flight envelope approved by USAATA (appendix B), approach and go-around procedures as outlined in TM 55-1510-206-10 proved to be adequate. Aviator preference

(techniques) varied as to when published procedures should be completed. Analysis of drop results showed that those aviators who completed the published procedures well in advance (one minute or one mile) of reaching the actual extraction point were more successful in attaining the criteria established for load survivability.

During the conduct of the test, 16 inadvertent ground contacts with the airplane main gear were experienced. If the main gear had not been extended, it is safe to assume that propeller contact would have resulted. With the gear retracted and the airplane in level flight, the propeller extends approximately 13-1/2 inches below the lowest point of the fuselage (discounting antenna installations).

1.3.3.3. Air Drop Procedures.

In order to complete air drop procedures properly and safely, a minimum of two crew members are required in the cargo compartment. During those operations which utilize two drop zones in a single sortie, one man cannot physically rig the extraction parachute for the second extraction. In order to complete emergency procedures, one man is required to be positioned at the parachute ejection rack manual release and one man positioned to cut the final restraint manually. Further, one of the two persons in the cargo compartment must be a qualified loadmaster. Loadmaster qualification becomes especially important when dealing in multiple extractions or when utilizing two drop zones in a single sortie.

Procedures outlined in section VI of TM 10-500-5 proved to be inadequate for LOLEX operations. Standard aerial delivery procedures from altitude are premised on the airplane being flown at a safe altitude and constant attitude immediately preceding, during, and following the extraction. This condition allows for the removal of tie-down devices and the completion of other pre-delivery procedures well in advance of reaching the drop point. It also allows for re-restraining the load following a malfunction after the extraction parachute has cleared the rack. LOLEX, however, required gross changes of airplane altitude and attitude in the last few minutes preceding the extraction sequence. The close proximity of the airplane to the ground during extraction also required that the airplane gain altitude rapidly immediately following the extraction sequence or expiration of the time allotted thereto.

Test results established that the minimum time required to complete the pre-extraction procedures was six minutes for single loads and ten minutes for multiple loads. No time was available for

re-restraining of the load following a malfunction with the extraction parachute free of the retaining rack.

1.3.4. Analysis.

1.3.4.1. LOLEX is in many ways identical or similar to standard aerial delivery of supplies and equipment. There are, however, certain distinct differences which require that changes or additions be made to current publications.

1.3.4.2. The preflight procedures contained in section II, chapter 3, TM 55-1510-206-10, are adequate for LOLEX operations. However, if an aerial delivery publication covering LOLEX is approved, it should contain aviator instructions for preflight inspection of rigging. Recommended instructions are outlined in section 1, appendix D.

1.3.4.3. In-flight procedures contained in section III, chapter 3, and emergency procedures (as modified by USAATA LOLEX Safety-of-Flight Release (appendix B) in chapter 4 of TM 55-1510-206-10, are satisfactory for conduct of LOLEX operations. Best load survivability will result if "Before Landing" procedures outlined in paragraphs 3-16 and 3-17, section III, chapter 3, TM 55-1510-206-10, are completed at least one minute or one mile prior to reaching the release point.

1.3.4.4. LOLEX operations will require the addition of one crew member in the cargo compartment. One of the two persons in the cargo compartment must be a qualified loadmaster.

1.3.4.5. In-flight air drop procedures outlined in section VI, TM 10-500-5, cannot be used for LOLEX operations. Section II of attached appendix D outlines recommended procedures for addition to TM 10-500-5.

1.4. ADDITIONAL COMMENTS.

1.4.1. Objective.

To insure that all data and comments pertinent to LOLEX operations not specifically covered elsewhere are presented for consideration.

1.4.2. Method.

As the test progressed, it was noted that certain factors not previously considered of major significance would, in fact, have considerable influence in determining successful completion of LOLEX operations. As these factors became apparent, they were introduced into the test sequence, data and comments were gathered, and impact on the system was evaluated. Specific areas covered were:

a. Drop Zone (DZ) requirements.

b. Drop Zone identification.

c. Extraction parachute deployment.

1.4.3. Results.

1.4.3.1. Drop Zone Requirements.

The USAATA-recommended minimum DZ length of 1600 feet between 50-foot barriers (appendix B) was verified during the service test at Fort Bragg, North Carolina. Several successful extractions were conducted on a tactical sod airstrip 1583 feet long and 135 feet wide with approximately 50-foot pine tree barriers on the approach and departure ends. The extraction parachute was released only after the aircraft reached the desired LOLEX altitude (3-6 feet).

In all test drops except one, the parachute release point was identified by a ground panel. As the test progressed ground personnel, by knowing the release point and the average extraction time and distance covered during extraction, were able to forecast accurately the load impact point ($\pm$ 100 feet).

Repeated drops were made into DZ 150 feet wide and 500 to 900 feet long (no barriers).

1.4.3.2. Drop Zone Identification.

In order to realize the full accuracy potential of the LOLEX system, it is essential that the DZ be accurately identified by the aircrew, both for azimuth and length. During the conduct of the test, best results were obtained when a high reconnaissance was conducted prior to the LOLEX run. Without this reconnaissance, accuracy of delivery deteriorated as the number of obstructions to visibility (trees, hills, etc.) surrounding the DZ increased. The display of pyrotechnic devices increased the

accuracy of delivery. On three nap-of-the-earth approaches, the aviators failed to make a successful extraction on the first pass.

1.4.3.3. Extraction Parachute Deployment.

A procedure was developed whereby the extraction parachute could be released during descent into confined areas, thus reducing the required DZ length. Several extractions were completed in which the ground party marked the impact point and the aviator determined the release point based on ground-speed and rate of descent. All extractions utilizing this procedure were successful and no adverse aircraft control problems were encountered. Accuracy of load impact was a factor of aviator judgment rather than computed distance.

1.4.4. Analysis.

Test results indicated that when properly executed LOLEX is an accurate method of aerial delivery. In order to achieve maximum accuracy of delivery it is essential that the aviator positively identify the DZ for both azimuth and length. This identification can best be accomplished by making a high aerial reconnaissance just prior to the approach. In the event a high reconnaissance is not feasible, some type of visual device must be employed which will allow the aviator to identify positively the azimuth and limits of the DZ at some point (approximately 1 mile or 1 minute) prior to reaching the DZ. Further, best results are obtained if the ground party marks the extraction parachute release point rather than the desired impact point. This procedure relies on computable distances rather than aviator judgment.

APPENDIX A

CHECK SHEET (LOLEX)
AIRCRAFT CONTROL AND CREW PROCEDURES

Missions will be flown within the following airspeed and flap ranges:

1. Airspeed - Minimum 75K - Max 85K with 15° flaps.
2. Airspeed - Minimum 85K - Max 100K with 7° flaps.

---

1. Aircraft data at load extraction:

   a. Airspeed ______________________________

   b. M. P. ______________________________

   c. RPM ______________________________

   d. Flaps ______________________________

   e. Attitude ____________________(S&L, Nose Up, etc)

   f. T. O. Gross Weight ______________________________

2. Describe any unusual aircraft reactions during extraction.

3. Could you easily identify drop zone, axis of flight, and release panel? If not, what procedures would have aided you?

4. What type final approach did you use? (Long flat final, power approach from 300 to 500 feet, power off approach, etc.)

5. What type approach do you feel would have been best for this mission?

6. What do you estimate your wheel to ground clearance was at extraction?

7. Do you consider a high recon of the DZ to be essential to satisfactory delivery? If so, why?

8. Do you consider air-crew procedures preflight briefing adequate, especially as to emergency procedures during extraction phase of the mission? Suggestions for improvement, if any.

9. Any additional comment you wish to make.

Name ____________________
Mission Number ____________
Type Load ________________
Load Weight ______________

APPENDIX B

FROM: CO USAATA EDWARDS AFB CALIF

TO: CG USATECOM ABERDEEN PROVING GROUND MD
PRES USAESWBD FT BRAGG NC
PRES USAAVNTBD FT RUCKER ALA
CG YUMA PG YUMA ARIZ

UNCLAS STEAV-E 7-4-15

MSG FOR AMSTE-BG (CAPT. ABROGAST). INFO USAESWBD, COL PIPER, USAAVNTBD, COL RANKIN, YUMA PG CAPT. GILKES. THIS MSG IN SIX PARTS.

PART I. REF USATECOM REG 385-6.

PART II. THIS ACTV HAS CONDUCTED AN ENGINEERING TEST FOR THE PURPOSE OF PROVIDING THE INFO NECESSARY TO RECOMMEND A SAFETY OF FLT RELEASE OF THE LOLEX AERIAL DELIVERY SYSTEM UTILIZING A CV-2B CARIBOU ACFT. AN INSTRUMENTED ACFT WAS USED FOR TESTS. IN ADDITION TO ACFT INSTRUMENTATION, ALL LOLEX DROPS WERE RECORDED WITH A FAIRCHILD FLT ANALYZER AND PHOTOGRAPHED FROM GROUND AND CHASE ACFT. PERSONNEL FROM YUMA PG, AESWBD AND AVNTBD PARTICIPATED IN TESTS. THE TESTS WERE CONDUCTED IN ACCORDANCE WITH FOLLOWING CRITERIA; A. ACFT SHOULD NOT BE ALLOWED TO CONTACT THE GROUND FOLLOWING ENGINE FAILURE DURING LOLEX DROP. B. LOLEX OPERATIONS IN FIELD WILL BE CONDUCTED SO THAT A SAFE SINGLE ENGINE RECOVERY AND CLIMB OVER A 50 FOOT OBSTACLE COULD BE ACCOMPLISHED FOLLOWING ENGINE FAILURE DURING LOLEX APPROACH SEQUENCE.

PART III. BASED ON ABOVE ASSUMPTIONS, THE FOLLOWING LOLEX FLT ENVELOPE WAS DEVELOPED AND IS RECOMMENDED: A. MINIMUM LOLEX APPROACH SPEEDS. (1) 24,000 LBS - 75 KNTS. IAS, (2) 26,000 LBS - 83 KTS IAS. (3) 28,500 LBS - 90 KTS IAS. THE MINIMUM LOLEX APPROACH SPEEDS LISTED ABOVE WERE BASED ON SINGLE ENGINE GO-AROUND CAPABILITY AT TEST WEIGHTS. B. MAXIMUM LOLEX APPROACH SPEEDS. (1) AT FLAP SETTINGS OF 15 DEGREES - 85 KTS IAS. (2) AT FLAP SETTINGS OF 7 DEGREES - 100 KTS IAS. THE

MAXIMUM LOLEX APPROACH SPEEDS LISTED ABOVE WERE BASED ON REQUIREMENTS FOR DESIRABLE AIRPLANE ATTITUDES AND FLAP STRUCTURAL LIMITATIONS. FLAP SETTINGS GREATER THAN 15 DEGREES SHOULD NOT BE USED BECAUSE OF LACK OF SINGLE ENGINE GO-AROUND CAPABILITY AT HIGHER FLAP SETTINGS. C. LOLEX AIRPLANE CENTER-OF-GRAVITY RANGES. THE CENTER-OF-GRAVITY ENVELOPE AS SPECIFIED IN "OPERATOR'S MANUAL, AC-1 ACFT", TM 55-1510-206-10 DTD JUNE 1962 MAY BE UTILIZED FOR LOLEX OPERATIONS.

PART IV. LOLEX FLT ENVELOPE RECOMMENDED ABOVE IS BASED ON FOLLOWING LOLEX CONFIGURATIONS FOR ALL GROSS WEIGHTS: A. FOR APPROACH SPEEDS UP TO 85 KTS IAS; (1) LANDING GEAR - DOWN, (2) FLAP SETTING - 15 DEGREES. (3) POWER - AS REQUIRED FOR LEVEL FLT. (4) PROPELLER CONTROL - TAKEOFF RPM SETTING. (5) RAMP DOOR - LEVEL. (6) CARGO DOOR - OPEN. (7) AUTOFEATHERING - OFF.

PART V. USING ABOVE LISTED CONFIGURATIONS AND FLT ENVELOPE, LOLEX DROPS OF LOADS RANGING FROM 1500 LBS TO 4000 LBS WERE SUCCESSFULLY ACCOMPLISHED AT DROP WHEEL HEIGHTS RANGING FROM 3 TO 12 FEET. THESE DROPS WERE ACCOMPLISHED USING BOTH CONSTANT HEIGHT STRAIGHT-IN APPROACHES AND TACTICAL APPROACHES OVER A SIMULATED 50 FOOT BARRIER. MINIMUM FIELD LENGTH REQUIRED TO EXECUTE TACTICAL LOLEX APPROACH CARGO DROP AND CLIMBOUT OVER 50 FOOT BARRIERS IS APPROXIMATELY 1600 FEET AT A GROSS WEIGHT OF 28,500 LBS, USING A 90 KT. APPROACH SPEED. FURTHER PERF. TESTS ON AN AIRPLANE INSTRUMENTED FOR PERF. WOULD BE REQUIRED TO ACCURATELY DETERMINE THIS DISTANCE FOR ANY COMBINATION OF CONDITIONS.

PART VI. SAFETY OF FLT CONSIDERATIONS PECULIAR TO LOLEX OPERATIONS: A. IT WAS DETERMINED THAT TESTS SIMULATING A HUNG LOAD CONDITION THAT: (1) CV-2B DOES NOT POSSESS ADEQUATE SINGLE-ENGINE CLIMB CAPABILITY WITH EITHER A 15 FOOT OR 22 FOOT EXTRACTION CHUTE FULLY DEPLOYED. (2) WITH A 22 FOOT EXTRACTION CHUTE DEPLOYED CV-2B WILL NOT CLIMBOUT OF GROUND EFFECT IN LOLEX CONFIGURATION WITH BOTH ENGINES AT TAKEOFF POWER. (3) WITH A 15 FOOT EXTRACTION CHUTE DEPLOYED, A POSITIVE RATE OF CLIMB IS POSSIBLE BUT

CLIMB PERF IS EXTREMELY MARGINAL IN ALL AIRPLANE CONFIGURATIONS AT ALL SPEEDS. THE RESULTS OF THESE TESTS INDICATE A REQUIREMENT FOR A DEVICE WHICH COULD BE EMPLOYED TO SEPARATE A HUNG EXTRACTION CHUTE AND/OR THE LOAD FROM THE AIRPLANE. B. SINGLE ENGINE PERF. DURING LOLEX DROP SEQUENCE: DETERMINED THAT SINGLE ENGINE PERF. IN LOLEX CONFIGURATIONS USED IN THIS TEST WAS SATISFACTORY. DUE TO THE MINIMUM HEIGHTS ABOVE GROUND LEVEL USED FOR LOLEX DROPS, A MODIFIED ZOOM FOLLOWED BY AN IMMEDIATE APPLICATION OF TAKEOFF POWER ON OPERATING ENGINE WAS SUCCESSFULLY EMPLOYED FOLLOWING SIMULATED ENGINE FAILURE. THE ZOOM WAS EXECUTED TO SPEEDS NOT LOWER THAN THE MINIMUM SINGLE ENGINE CONTROL SPEEDS LISTED IN THE OPERATOR'S MANUAL FOR THE APPROPRIATE WEIGHT. C. ALL EXTRACTIONS WERE CONDUCTED IN A NON-SIDESLIP APPROACH AND IT IS RECOMMENDED THAT THIS TECHNIQUE BE USED ON ALL LOLEX EXTRACTIONS; I. E. USE A CRAB RATHER THAN A SIDESLIP DURING A CROSSWIND APPROACH.

1330 hours 7 April 1964

John C. Kidwell, Chief, Eng. Div
Phone 46191

RICHARD J. KENNEDY, JR.
Lieutenant Colonel, TC
Commanding

APPENDIX C

DESCRIPTION AND ANALYSIS OF MALFUNCTIONS

Malfunction Number 1.

The load involved was a 1/4-ton truck rigged to break away from the platform on contact with the ground. (Weight: 2900 pounds.) As the airplane passed over the drop zone, the copilot activated the extraction parachute release mechanism and the loadmaster reported that the parachute had cleared the rack. The parachute failed to deploy behind the airplane and the load failed to extract. The height and width of the load precluded personnel on the aircraft from determining what had happened to the parachute. Because final restraint was secured on the aft end of the load, the load could not be jettisoned without personnel moving aft of an unsecured load. Ground observers and photo coverage verified that the pendulum loop on the parachute bag had hung on the roller conveyor and that the parachute was dangling over the edge of the ramp.

A review of onboard photo coverage of previous drops and repeated static drops revealed that in all cases the 22-foot ring slot extraction parachute contacted the airplane cargo ramp in the level position.

As a corrective measure a pendulum hook was fabricated and installed which moved the pivot point for the pendulum loop approximately 9-1/2 inches aft of its position in the standard installation. During the remainder of the test, no case of the extraction parachute contacting the ramp because of the pendulum hook occurred. The final restraint was also moved to the forward end of the load. This allowed for manual cutting and instantaneous jettisoning of the load.

Malfunction Number 2.

As the airplane moved across the drop zone the extraction parachute release was normal. The extraction line extended fully, however, the parachute failed to deploy and exert adequate extraction force on the load.

The loadmaster announced malfunction, the pilot caused the airplane to climb rapidly at which time the final restraint installed

on the forward end of the load was cut and the load gravity extracted.

It was determined that chute malfunction was due to material failure.

Malfunction Number 3.

At the proper time, the extraction parachute release mechanism was activated and the chute fell clear of the rack. The parachute pendulum action was, however, arrested by a failure of the pilot chute bag retaining pin to release. The parachute fell to the floor of the airplane.

The loadmaster announced malfunction and the load was jettisoned in the same manner described in Malfunction Number 2.

It was determined that the malfunction occurred due to material failure of the pilot chute bag retaining pin. A new type pin was fabricated and no further failure due to this cause occurred.

Malfunction Number 4.

Again, the extraction parachute cleared the rack but was arrested in its pendulum action by a failure of the pilot chute bag retaining pin to release. The load was jettisoned as previously described.

It was determined that the malfunction occurred because of material failure of the retaining pin grommet. A new grommet was designed and no further malfunction occurred.

Findings or Conclusions.

Because no method was available to separate the extraction parachute from the load, it was determined that the only feasible emergency procedure once the extraction parachute had cleared the rack, but failed to extract the load, was to jettison the load. If a device had existed to separate the extraction parachute from the load without requiring a crew member to move aft of the load, all four loads could have been saved. Further, in the event the extraction parachute should deploy properly and break the load free of final restraint and the load subsequently fail to clear the airplane, a dangerous situation would exist (appendix B).

APPENDIX D

SECTION I

AVIATOR'S PREFLIGHT INSPECTION OF LOAD AND EXTRACTION PARACHUTE SYSTEM

1. Insure that extraction line is fairly taut and tied to release clip located at rear end of cargo ramp.

2. Inspect extraction parachute and parachute release rack assembly:

a. Parachute V rings properly secured in rack.

b. Insure that safety cord on deployment bag passes over the extraction line and over the bent V ring.

c. Check rack manual release mechanism for freedom of movement.

d. Check pendulum line properly secured in pendulum line hook.

e. Check extraction parachute safety line properly installed.

3. Check extraction line properly stowed and secured to aircraft floor.

4. Check roller conveyors for proper installation.

5. Check attaching point of extraction line to load. (For breakaway loads extraction point must be on the load not on the platform.)

6. Check load and platform for:

a. Proper tie-down in accordance with G-force criteria.

b. Alignment of platform with buffer boards.

c. Security of load to platform.

d. Installation of final restraint. Final restraint strength cannot exceed extraction force exerted by extraction parachute. (For break-away loads the final restraint must be to the load not the platform.)

7. Check floor of aircraft for loose equipment.

8. Check sides of aircraft for protrusions or dangling objects which might interfere with load extraction.

9. Check forward attaching points of extraction parachute safety line.

APPENDIX D

SECTION II

IN-FLIGHT AIR DROP PROCEDURES
(Recommended addition to TM-10-500-5)

Normal Sequence of Operations: LOLEX is in many ways identical to standard air drop of supplies and equipment. There are, however, some very significant differences, the most important of which are: (1) Gross changes in aircraft attitude and altitude in the last few minutes preceding the extraction sequence, (2) the close proximity of the aircraft to the ground during the extraction sequence, and (3) a necessity to gain altitude rapidly immediately following extraction. The above conditions require that the following procedures be used:

a. Six minutes out. (Ten minutes for dual or multiple extractions) Six minutes prior to reaching the release point the pilot turns on the red light and notifies the loadmaster. The loadmaster then performs the following steps:

(1) Insures that all personnel in the cargo compartment are wearing parachutes.

(2) Checks all platform or skidboard lashings and all container sling straps for security.

(3) Makes a physical inspection of the pendulum extraction system to insure that each component is positioned correctly.

(4) Makes a visual inspection of the load.

(5) Requests that the crew chief open the cargo door and lower the cargo ramp to the level position. Advises the crew chief when the ramp is level.

(6) Removes all forward restraint except forward buffer boards.

(7) Takes a position at foremost point of cargo compartment.

(8) Notifies the pilot that the above steps have been accomplished.

b. One minute out (Two minutes for dual or multiple extractions.) One minute prior to reaching the release point the loadmaster and crew chief perform the following steps:

(1) Loadmaster insures that all personnel are forward of the load to be extracted.

(2) Crew chief positions himself by the pendulum rack emergency release.

(3) Loadmaster removes all remaining tie-down devices between the load and the cargo floor, starting from rear of aircraft and working forward, and doublechecks to make sure that all have been removed. The load is now restrained from movement rearward by the tie-down assembly or shear straps (final restraint).

(4) Loadmaster unties extraction parachute safety tie line and draws entire length forward of load.

(5) Loadmaster positions himself by the final restraint device with manual cutting device ready for activation if required.

(6) Loadmaster notifies pilot that foregoing steps have been completed.

c. At Release Point: Upon reaching the release point the pilot calls out "green light," at which time the copilot simultaneously activates the green light switch and the pendulum ejector switch. If the extraction chute has not cleared the rack by the time the crew chief sees the green light, the crew chief, with no other command, activates the manual pendulum ejector. The loadmaster announces "chute released or chute malfunction" followed by "load clear or load malfunction." Caution: It is essential that the loadmaster differentiate between a malfunction of the chute release and a malfunction after the chute release.

d. After Release:

(1) Crew chief closes cargo door and raises cargo ramp.

(2) Loose objects in the cargo compartment are secured.

(3) Pilot is notified that the foregoing steps have been completed.

Operation for Malfunction: The requirement exists for the airplane to gain altitude immediately after the LOLEX sequence time expires. Therefore, the only emergency procedure employed after the extraction parachute has cleared the rack is to jettison the load.

a. Ramp and Cargo Door Failure.

(1) Notifies the pilot of the failure.

(2) On order of pilot activates manual operation procedures.

(3) If door and ramp still do not open, notifies pilot.

b. Parachute Fails to Release from Rack.

(1) Notifies pilot of the failure.

(2) Secures each load for rearward restraint. Removes extraction parachute of forward load from adjacent load after restraint has been installed. Repeats procedures for each load as required.

(3) Removes extraction parachute from rack.

(4) Notifies pilot of steps taken and that cargo door and ramp are clear for closing.

(5) Completes restraint of all loads following procedures in paragraph 16.

(6) Notifies pilot that all steps have been completed.

c. Parachute Falls on Floor or Ramp - Parachute Fails to Deploy - Parachute Fails to Release Load.

(1) Loadmaster informs pilot "Load malfunction."

(2) Pilot initiates steep climb at which time loadmaster manually cuts final restraint allowing load to be gravity extracted.

(3) After load clears aircraft complete steps in 23d above.

Caution: For any malfunction other than that of the cargo door and ramp, do not close the door and ramp until all steps are completed.

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Final Report, 8 September 1964
DA Proj Nr Unknown (USATECOM Proj Nr 4-4-7475)
198 pp, 13 Illus.

Tests were conducted to determine suitability of LOLEX for use with CV-2B aircraft. It was concluded that LOLEX is suitable for Army use provided recommended modifications are incorporated.

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